



US009152837B2

(12) **United States Patent**
Matos

(10) **Patent No.:** **US 9,152,837 B2**
(45) **Date of Patent:** **Oct. 6, 2015**

(54) **APPARATUS AND METHOD FOR
VERIFYING THE IDENTITY OF AN AUTHOR
AND A PERSON RECEIVING INFORMATION**

(76) Inventor: **Jeffrey A. Matos**, New Rochelle, NY
(US)

(*) Notice: Subject to any disclaimer, the term of this
patent is extended or adjusted under 35
U.S.C. 154(b) by 237 days.

(21) Appl. No.: **13/563,399**

(22) Filed: **Jul. 31, 2012**

(65) **Prior Publication Data**

US 2012/0314048 A1 Dec. 13, 2012

Related U.S. Application Data

(63) Continuation-in-part of application No. 12/157,469,
filed on Jun. 11, 2008, now Pat. No. 8,233,672.

(60) Provisional application No. 60/934,043, filed on Jun.
11, 2007.

(51) **Int. Cl.**
G06K 9/00 (2006.01)
G06F 21/32 (2013.01)
G07C 1/10 (2006.01)

(52) **U.S. Cl.**
CPC **G06K 9/00** (2013.01); **G06F 21/32** (2013.01);
G06K 9/00899 (2013.01); **G07C 1/10** (2013.01)

(58) **Field of Classification Search**
USPC 382/117, 118
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

5,229,764 A * 7/1993 Matchett et al. 340/5.52
6,542,624 B1 * 4/2003 Oda 382/117
2012/0140993 A1 * 6/2012 Brusio et al. 382/118

* cited by examiner

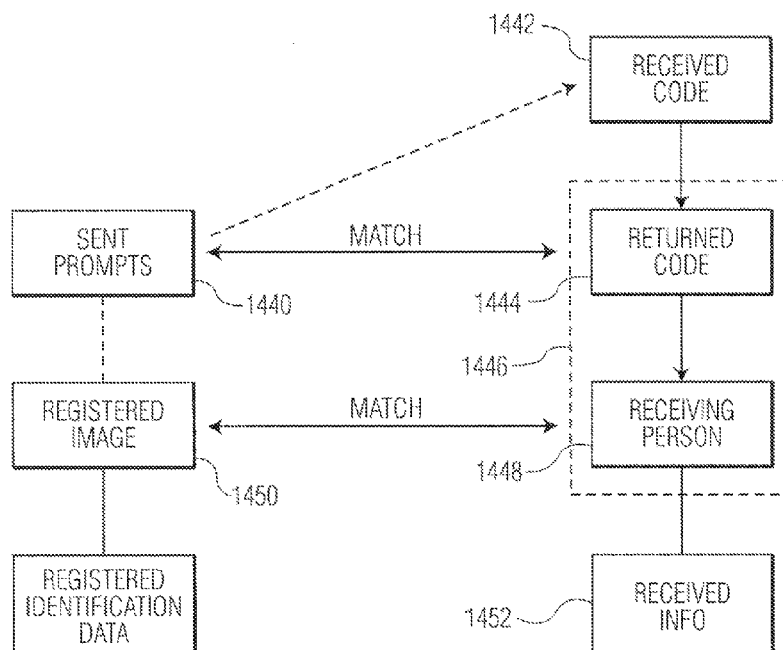
Primary Examiner — John Strege

(74) *Attorney, Agent, or Firm* — Karl F. Milde, Jr.; Eckert
Seamans Cherin & Mellott, LLC

(57) **ABSTRACT**

Apparatus for identifying a person who wishes to receive a computer file, or to input computer information, where identifying information for each of a plurality of registered individuals is stored in a database, calls for capturing images of an individual requesting to receive or alter computer information, and determining whether this individual is the same as one of the registered individuals whose identifying information is stored in the database. The stored identifying information includes both an alphanumeric identifier and images of a unique, visually observable biologic identifier on a body portion of each registered individual. The specificity of the identification process is enhanced by storing registered examples of altered biological information in the database, by causing the computer source to induce an alteration in a biologic identifier of a requesting person at the time of the request, and by comparing the altered requesting person information to stored information.

62 Claims, 32 Drawing Sheets



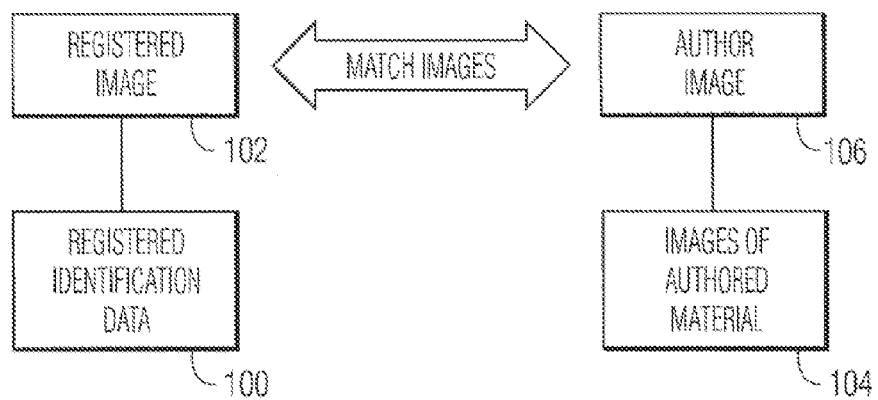


FIG. 1

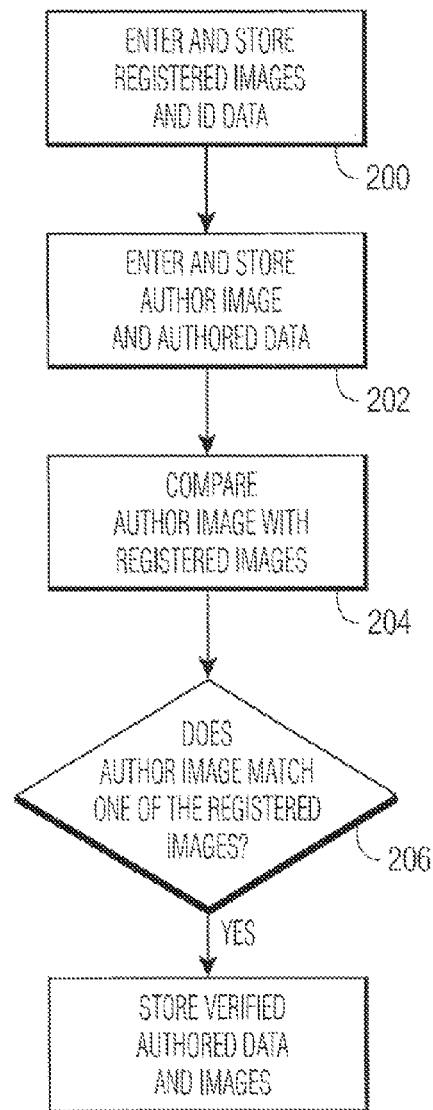


FIG. 2

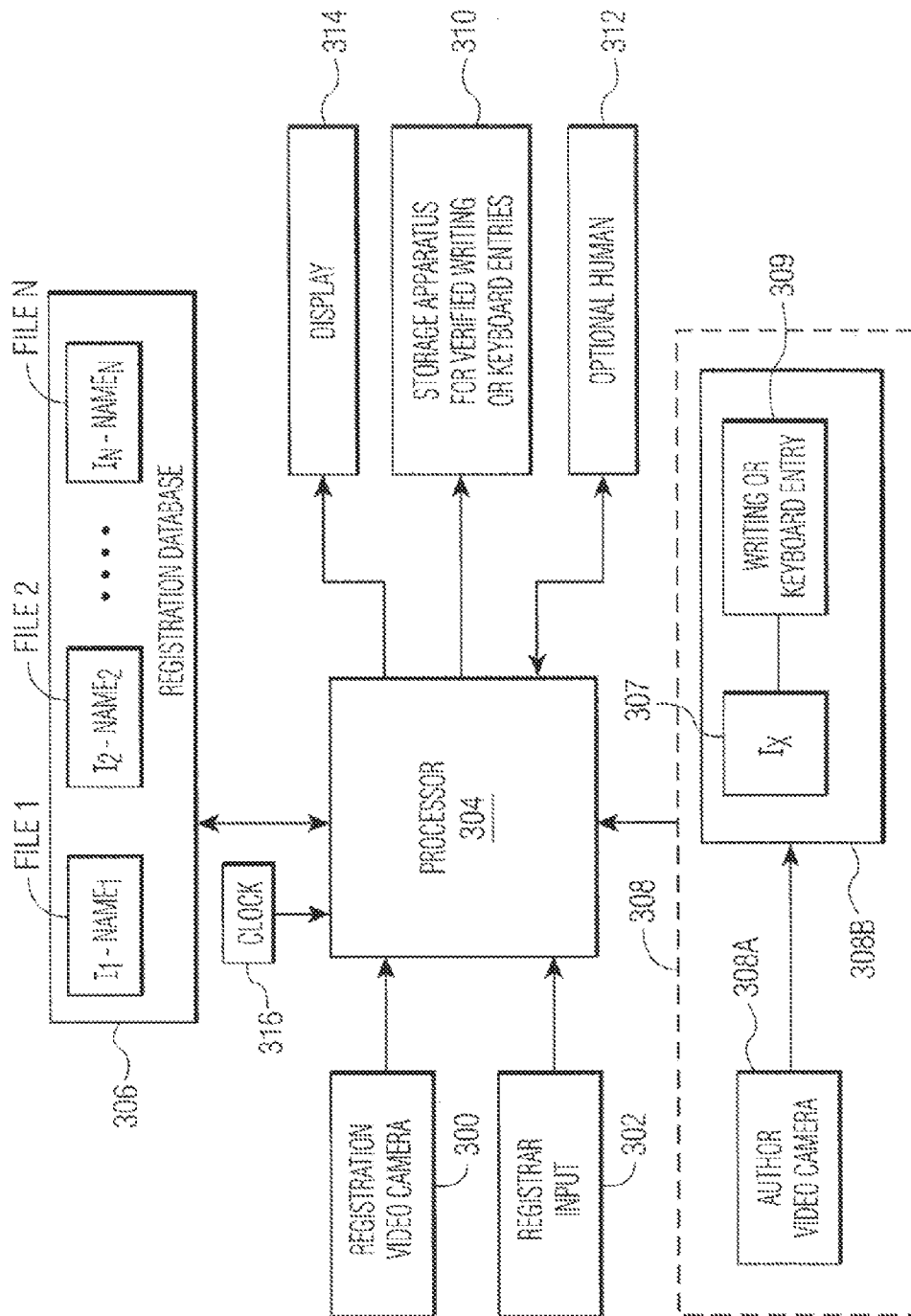


FIG. 3

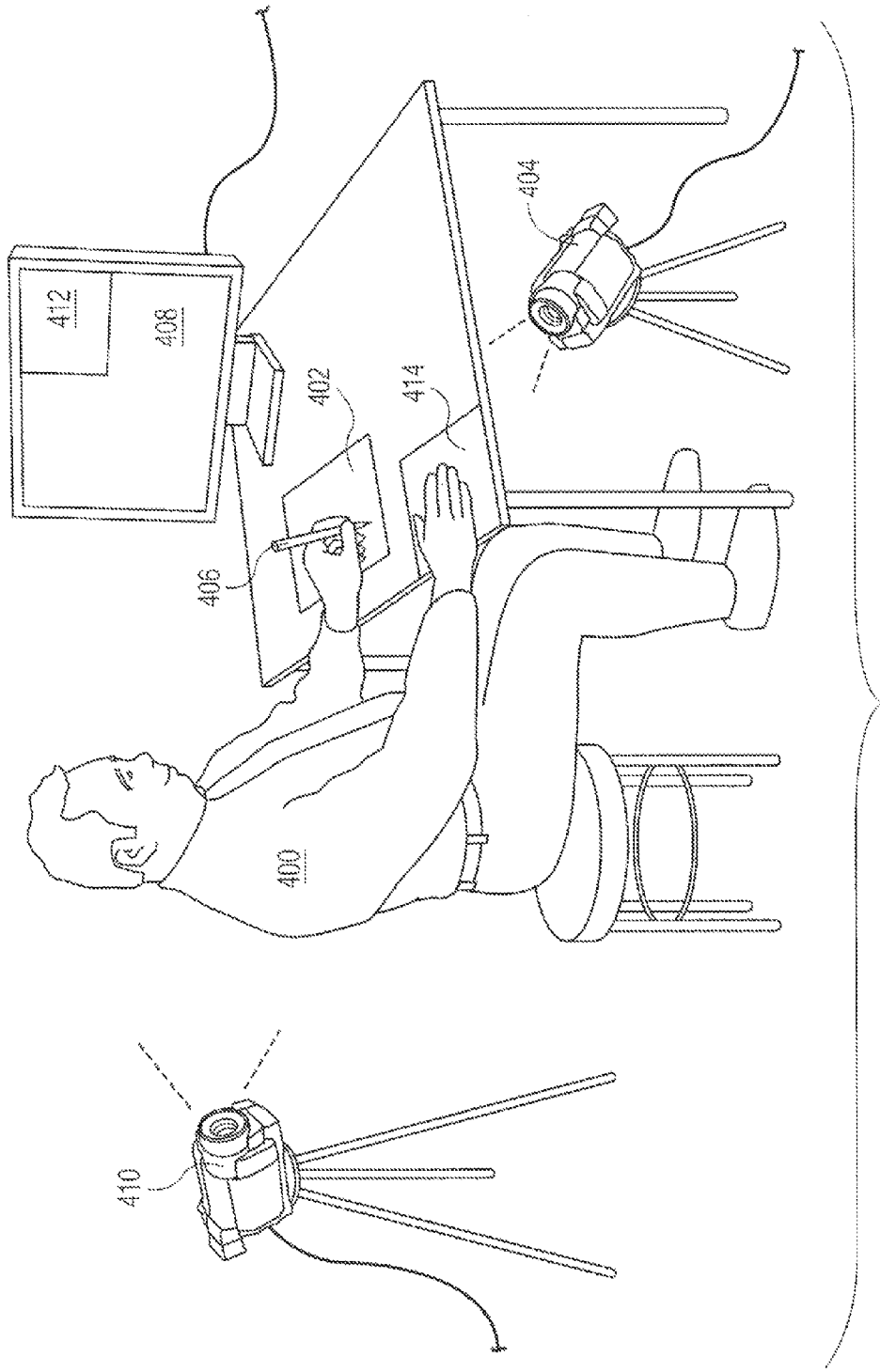


FIG. 4

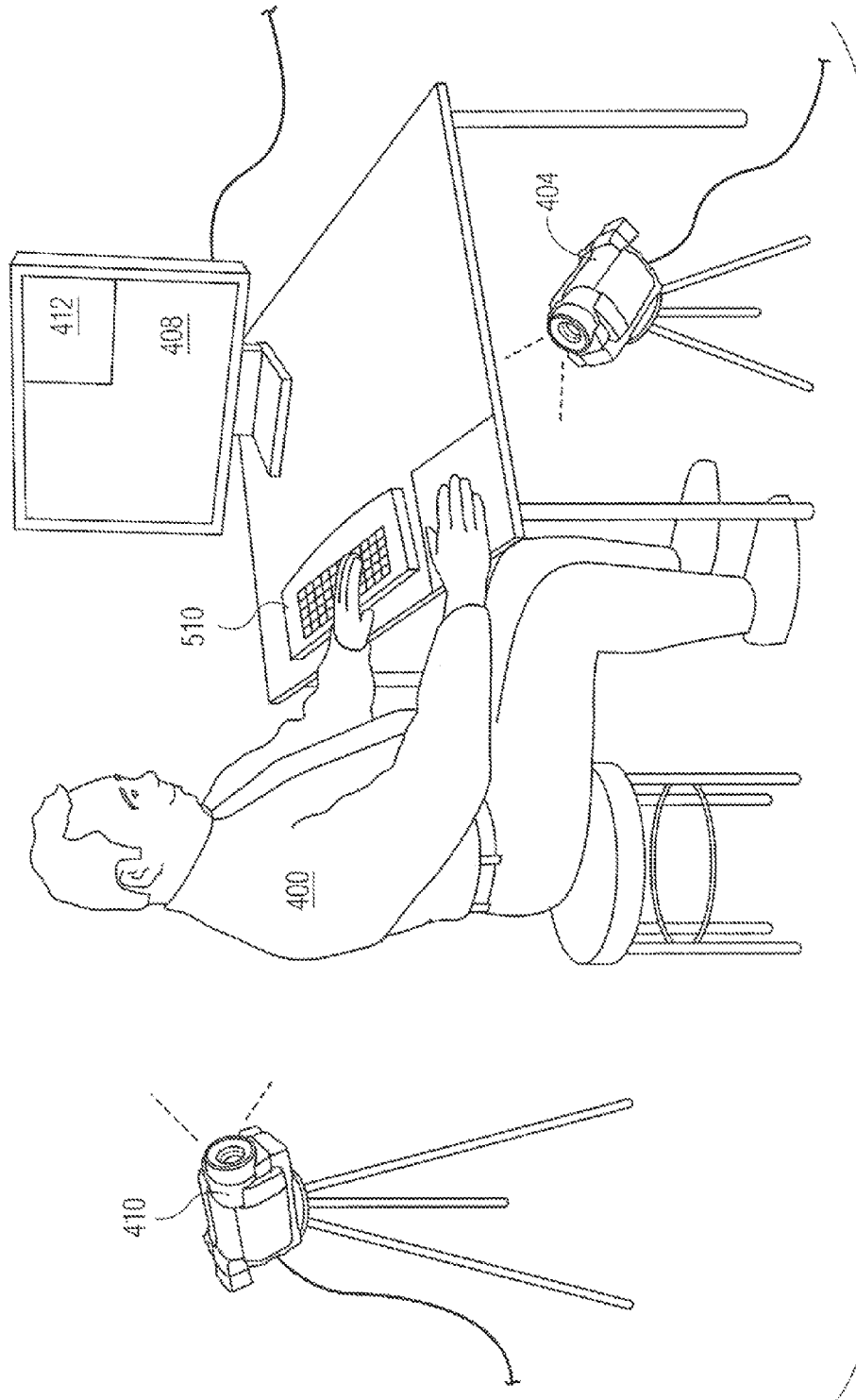
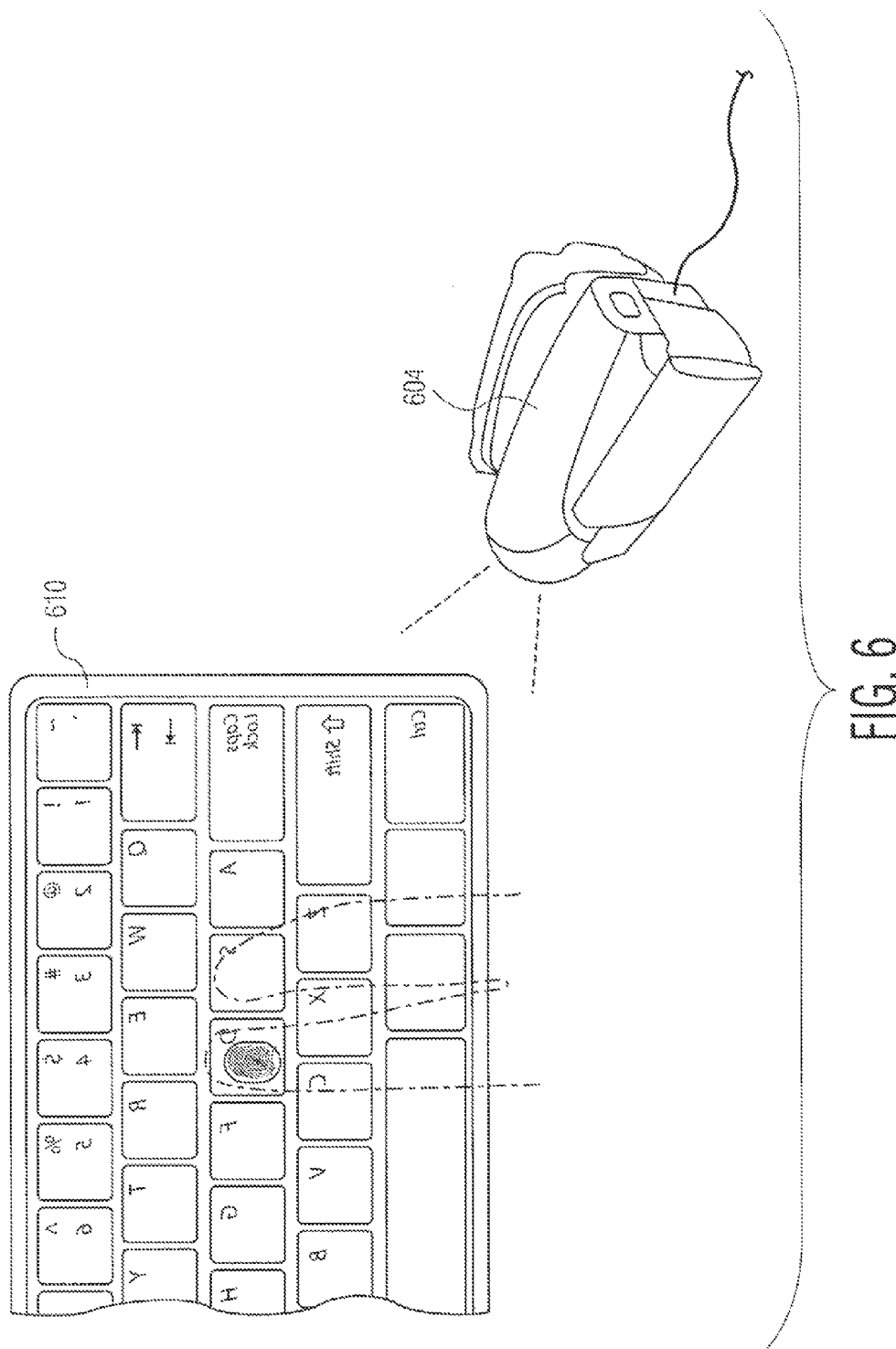


FIG. 5



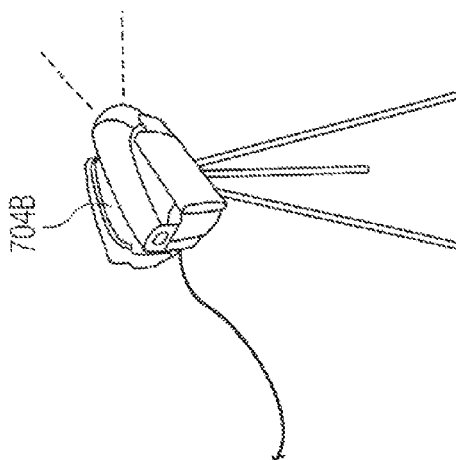
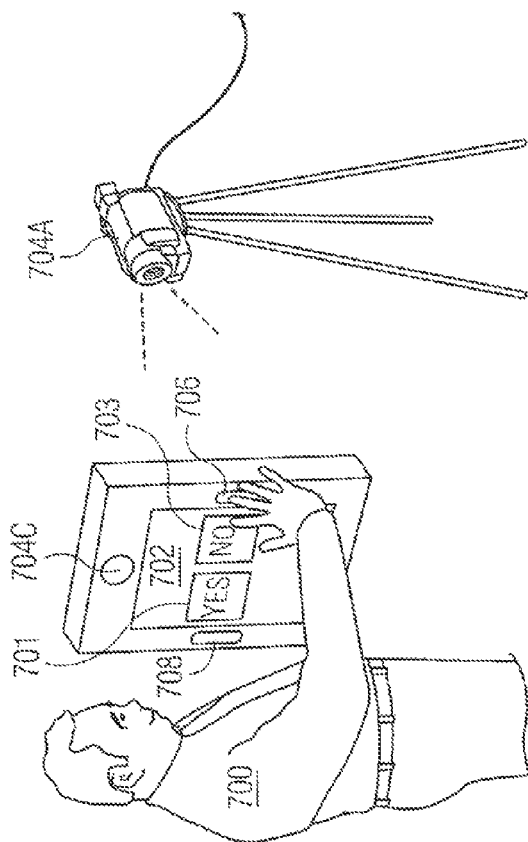
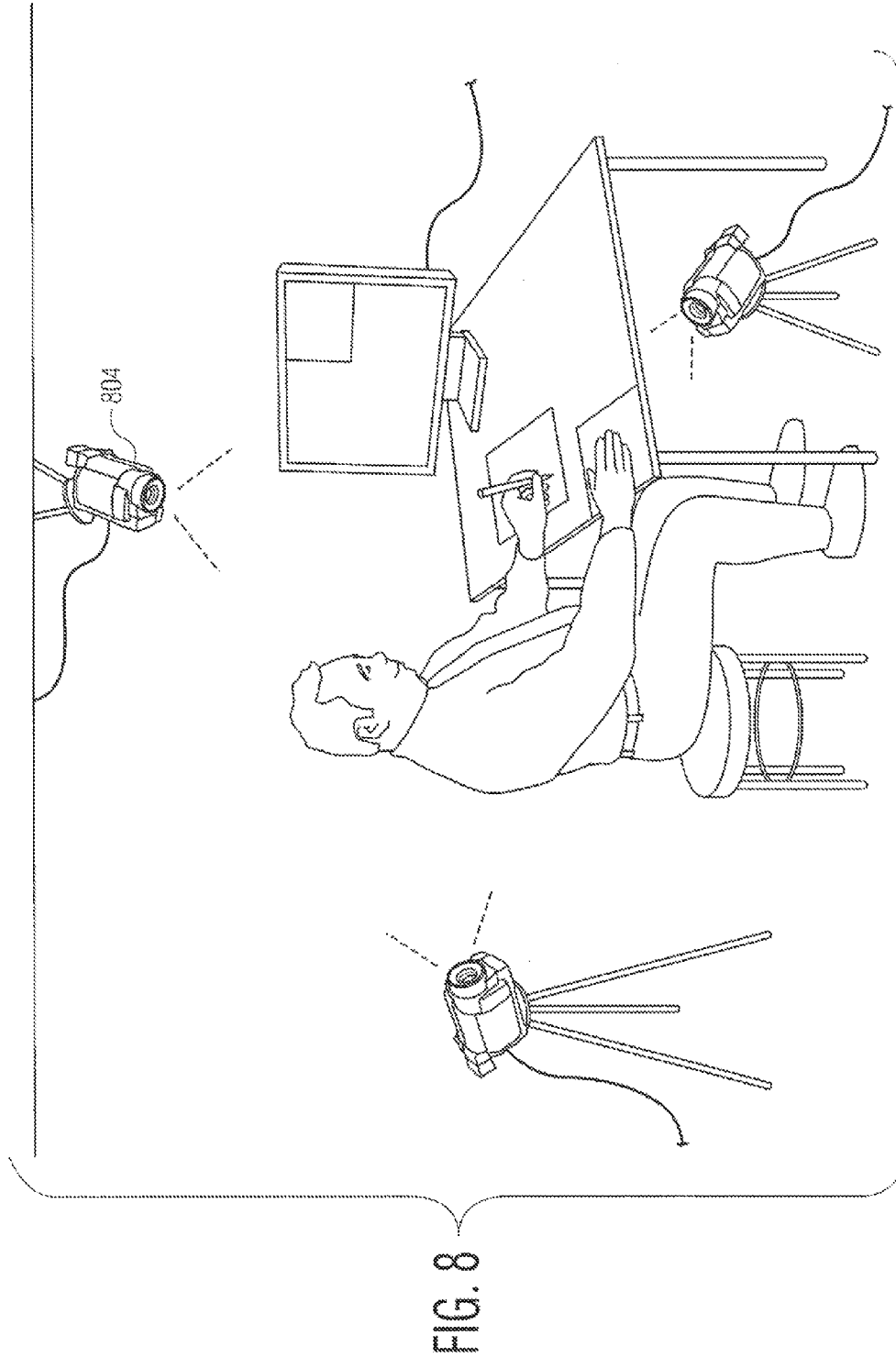


FIG. 7



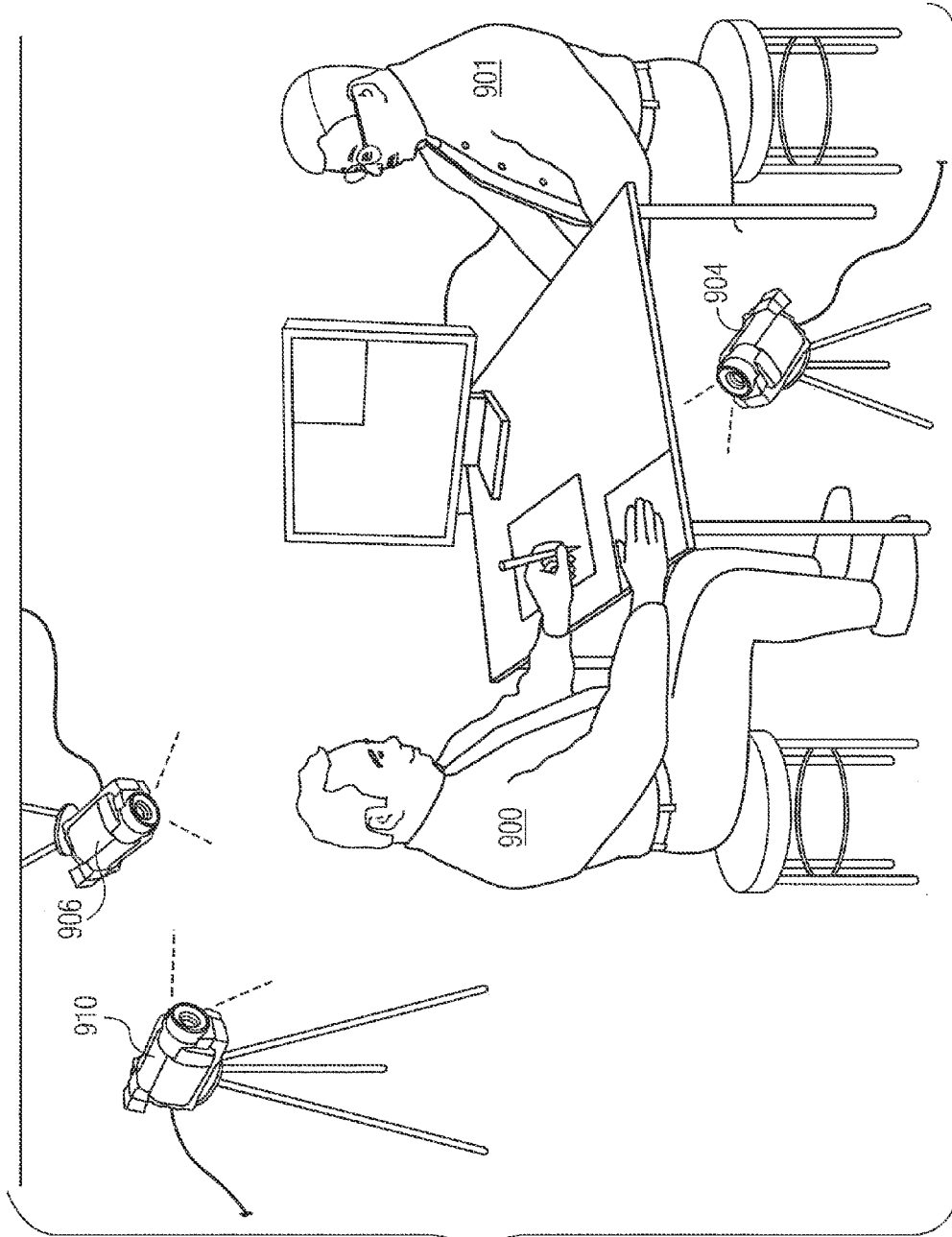


FIG. 9

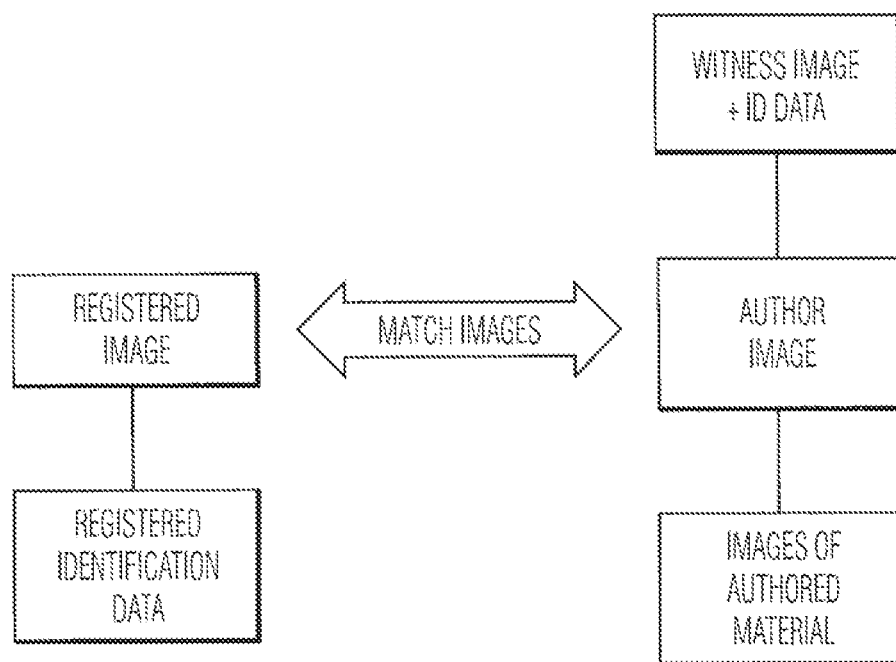


FIG. 10

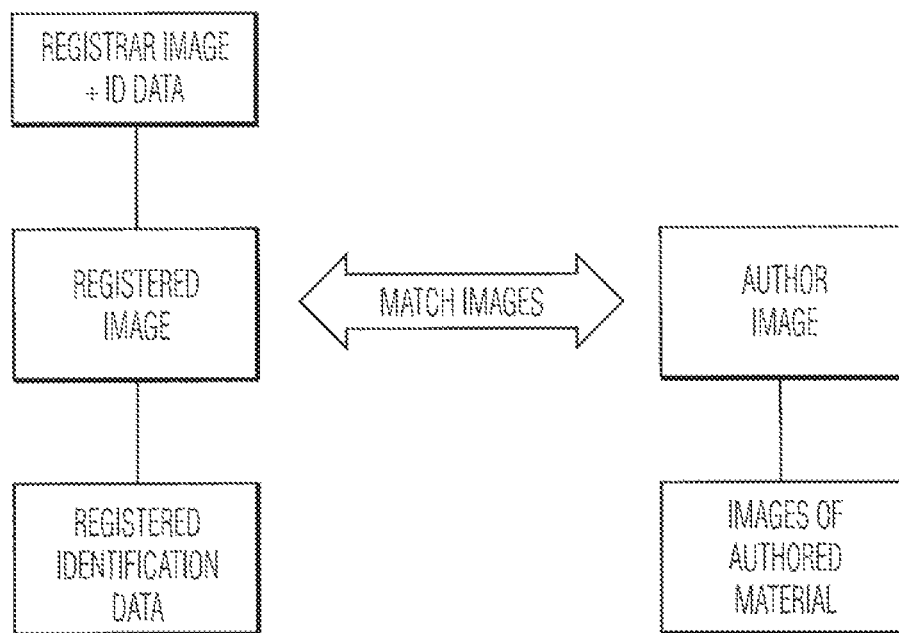


FIG. 11

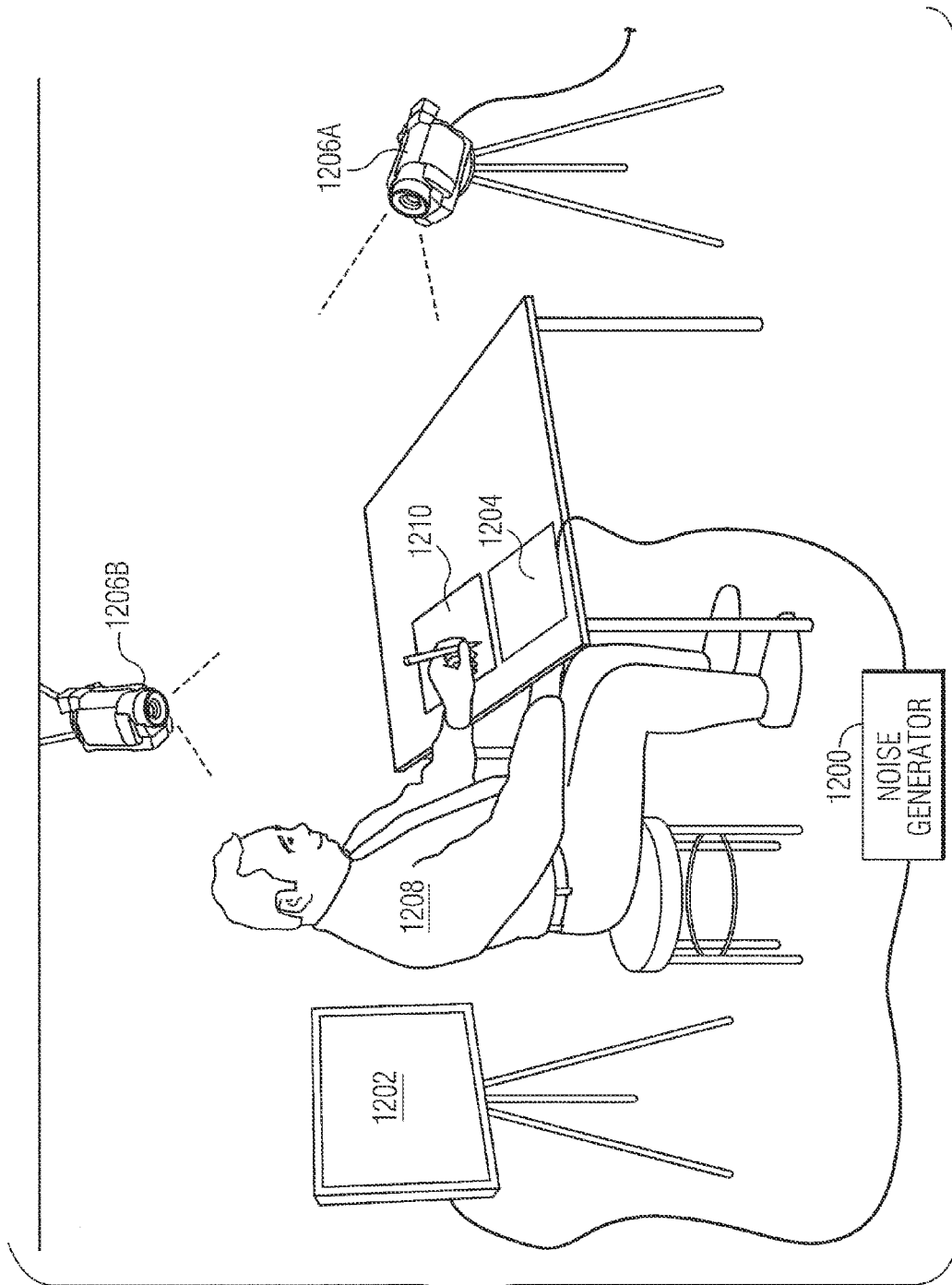


FIG. 12

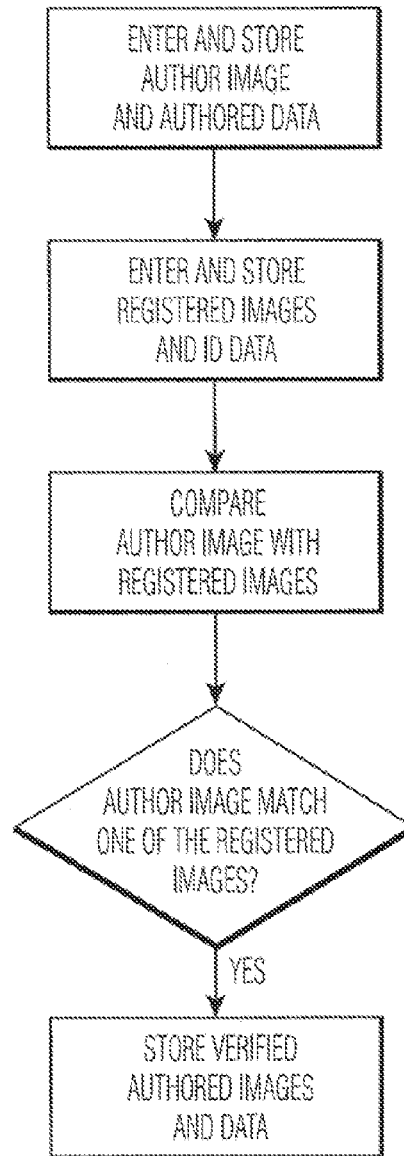


FIG. 13

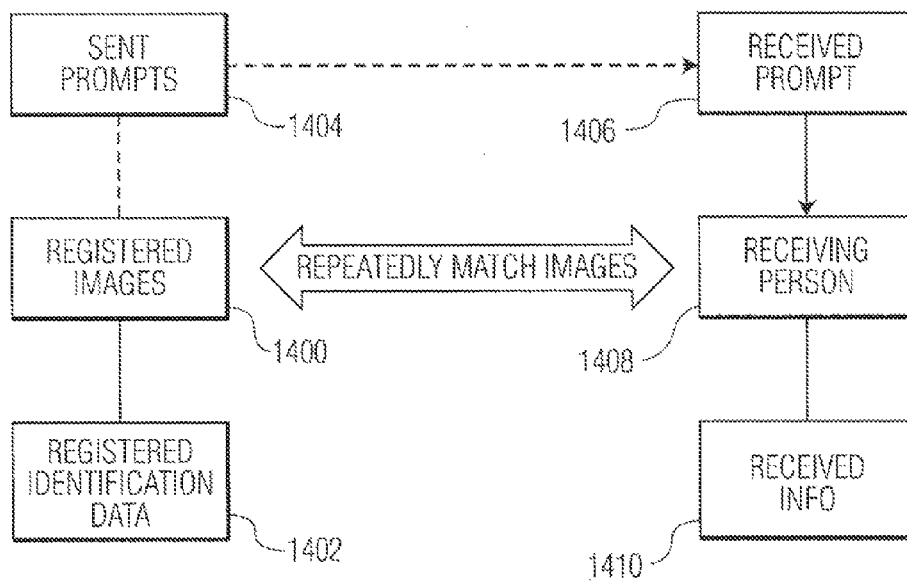


FIG. 14A

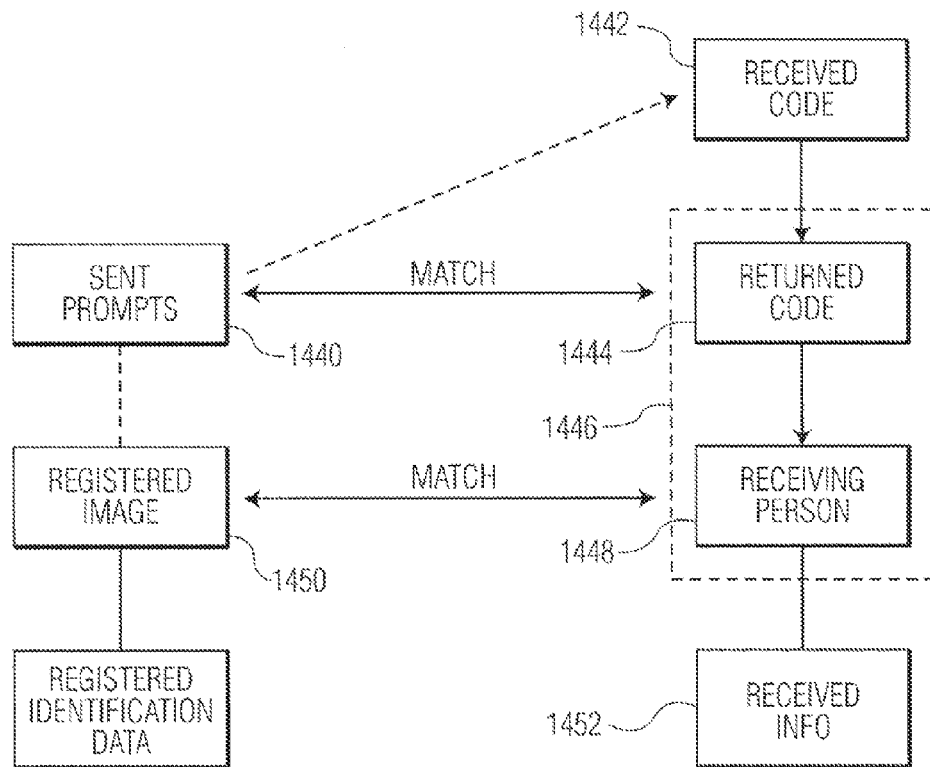


FIG. 14B

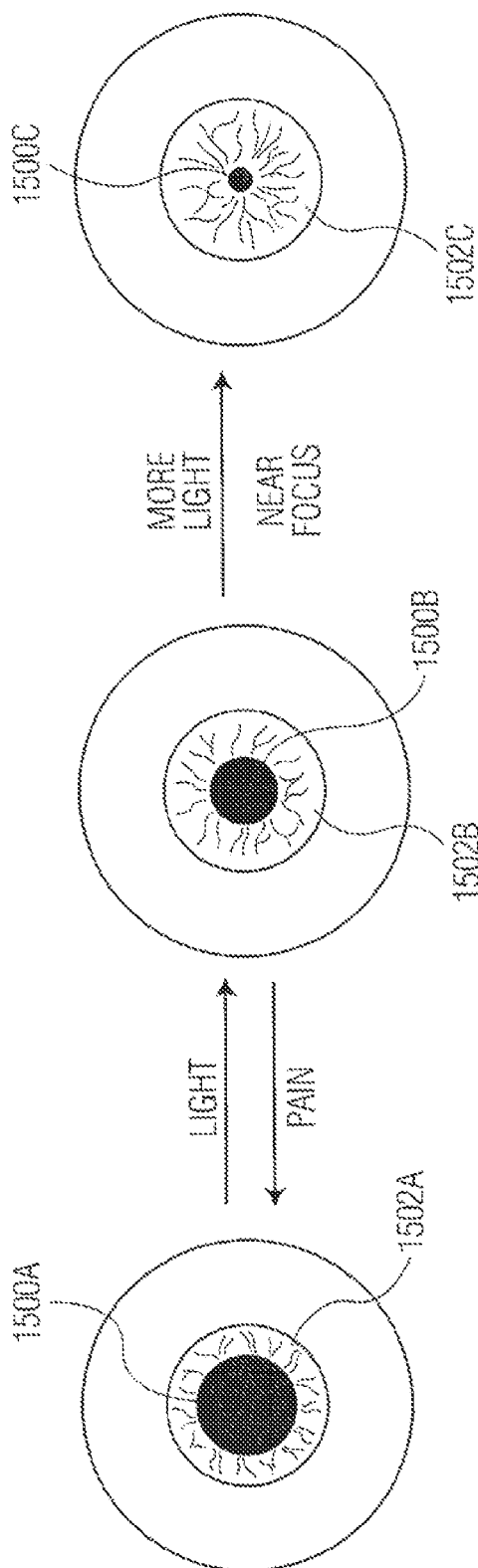


FIG. 15

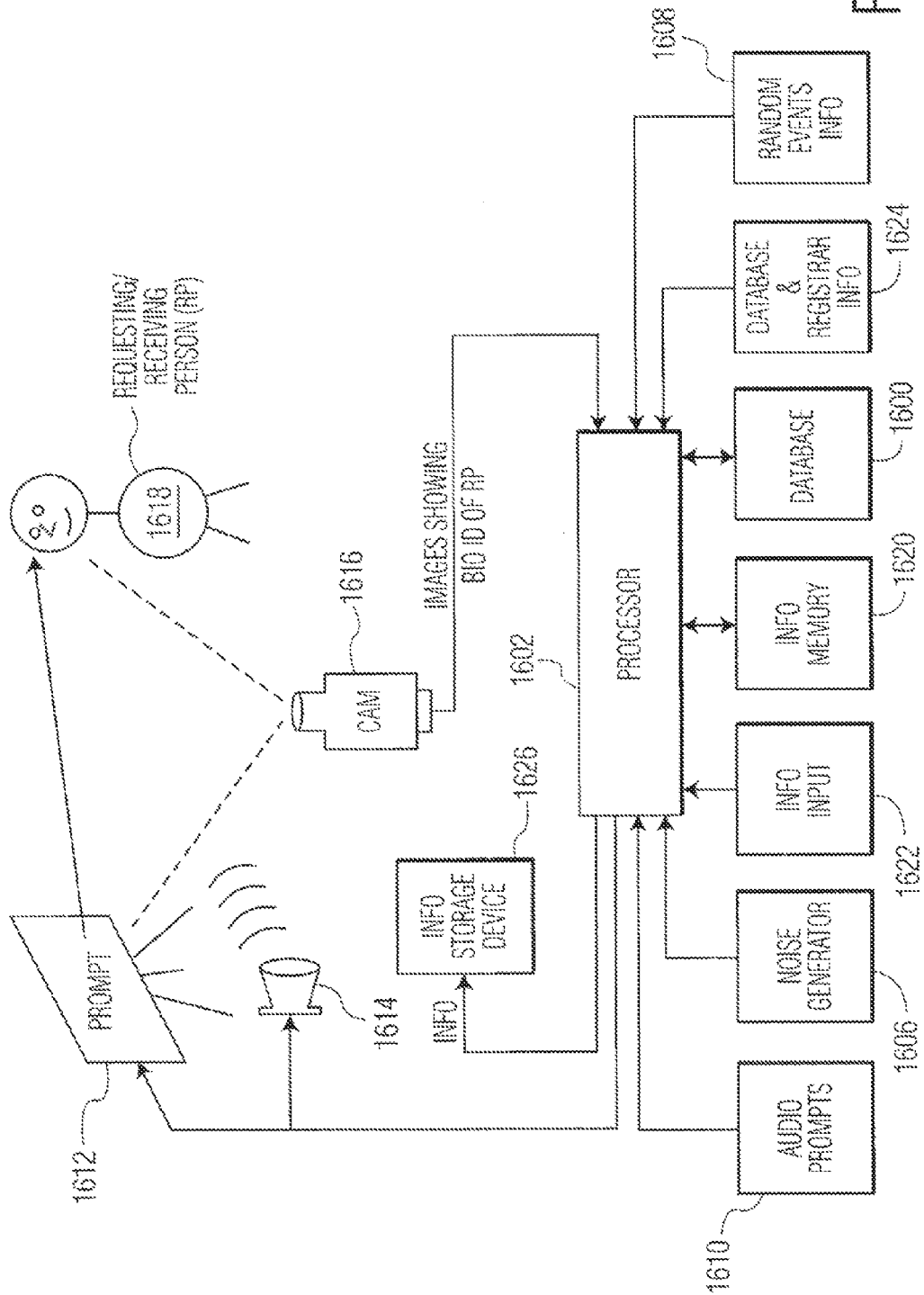
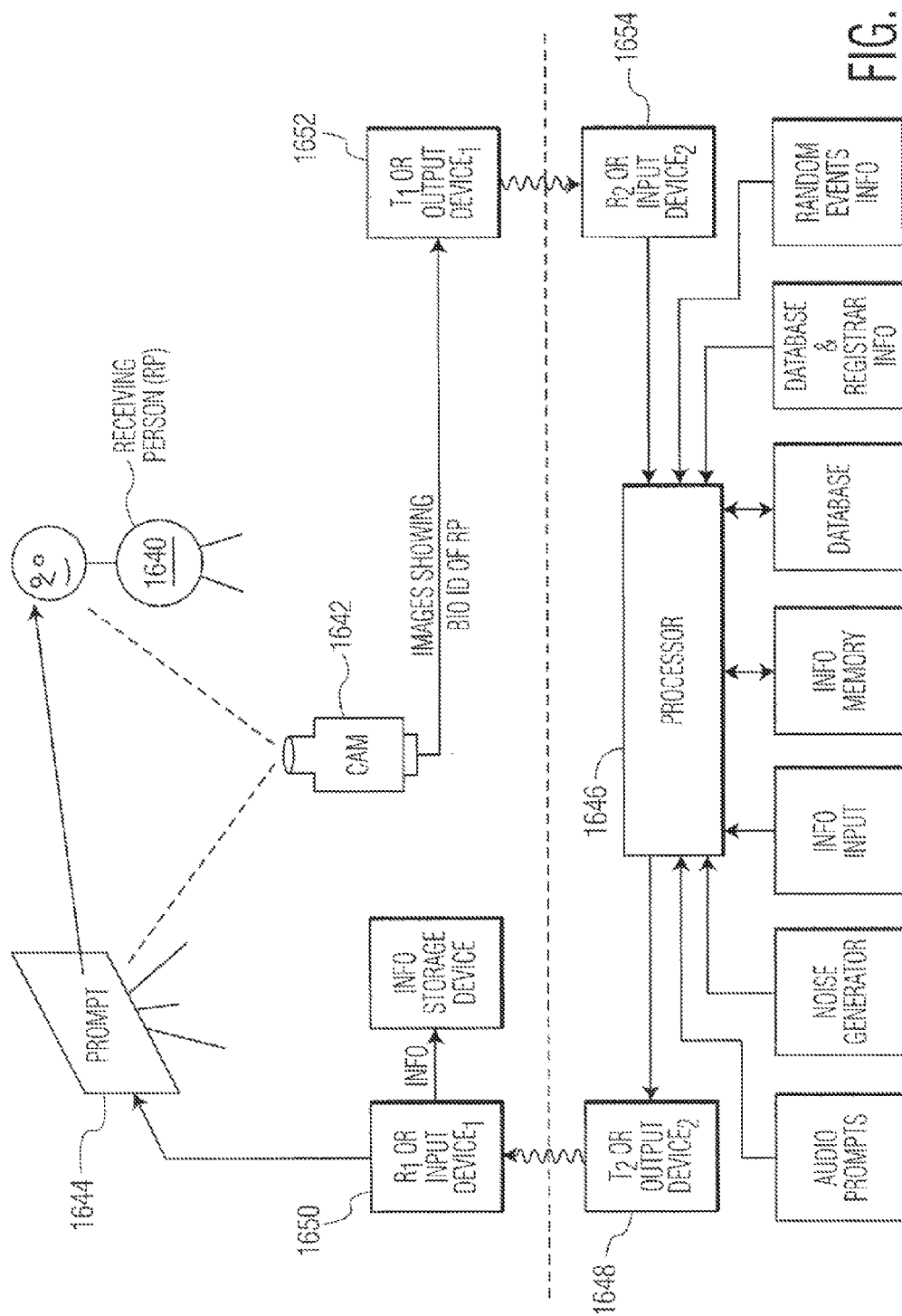



FIG. 16A





 DEPARTMENT OF HEALTH AND HUMAN SERVICES

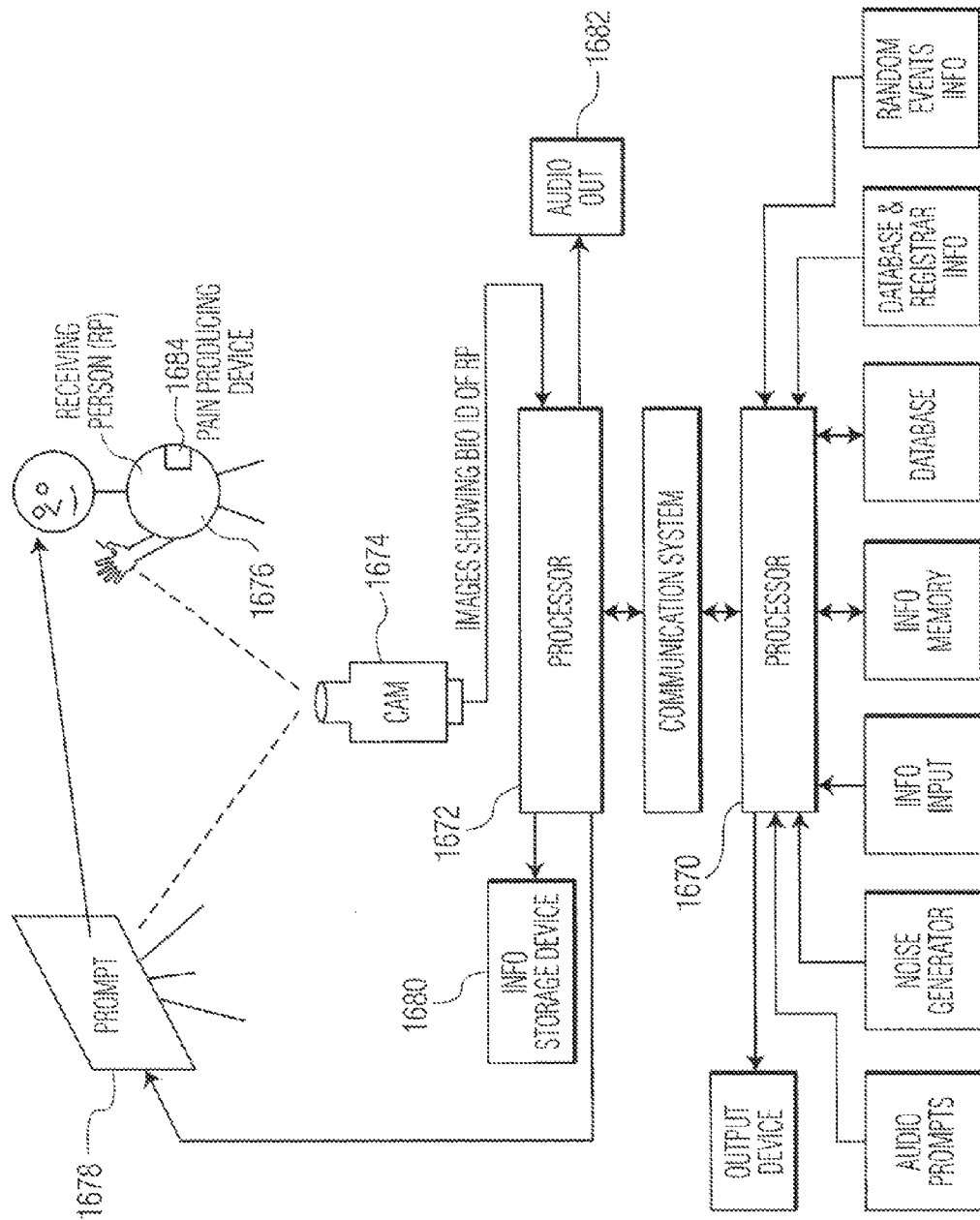
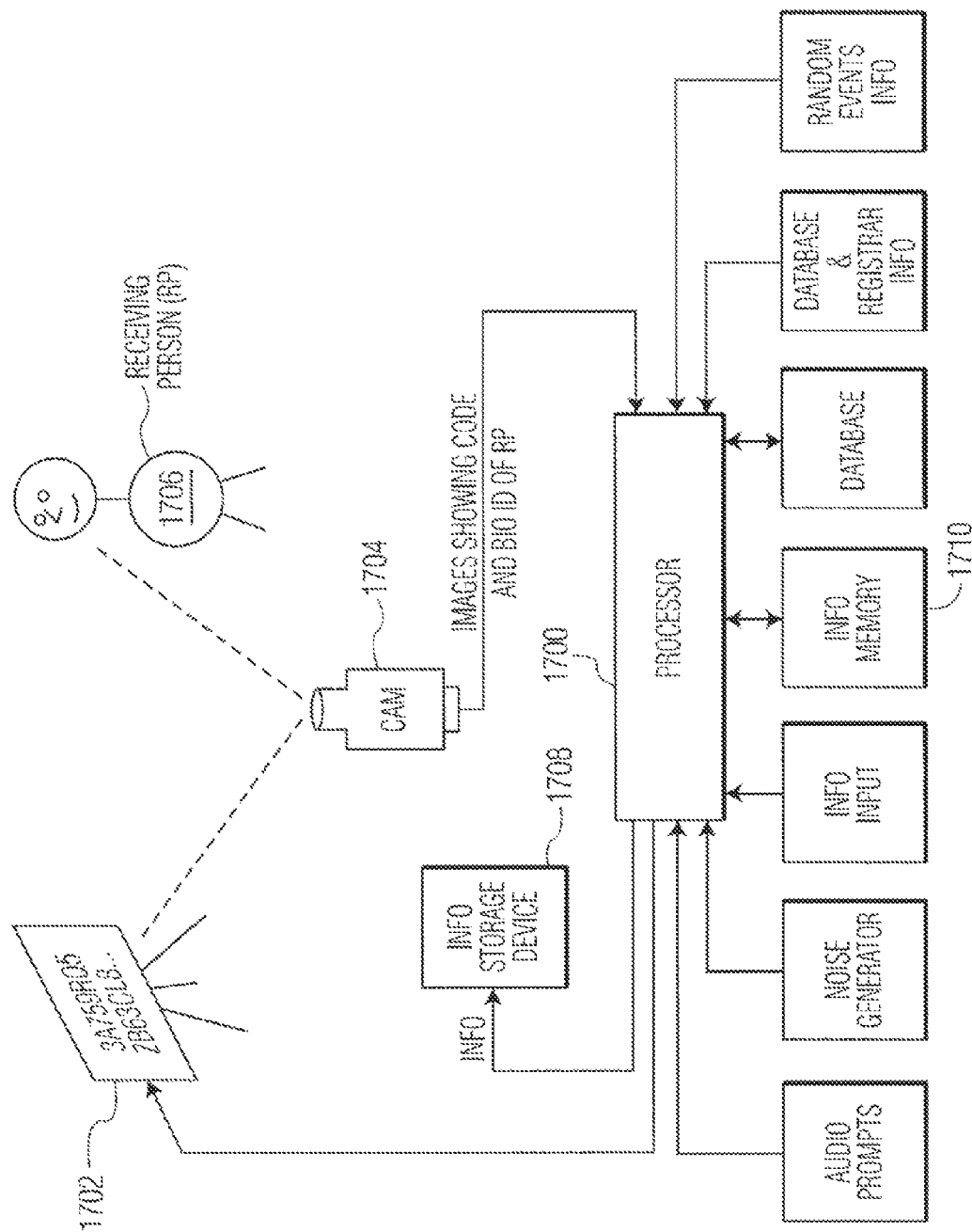


FIG. 16C



AL
LE

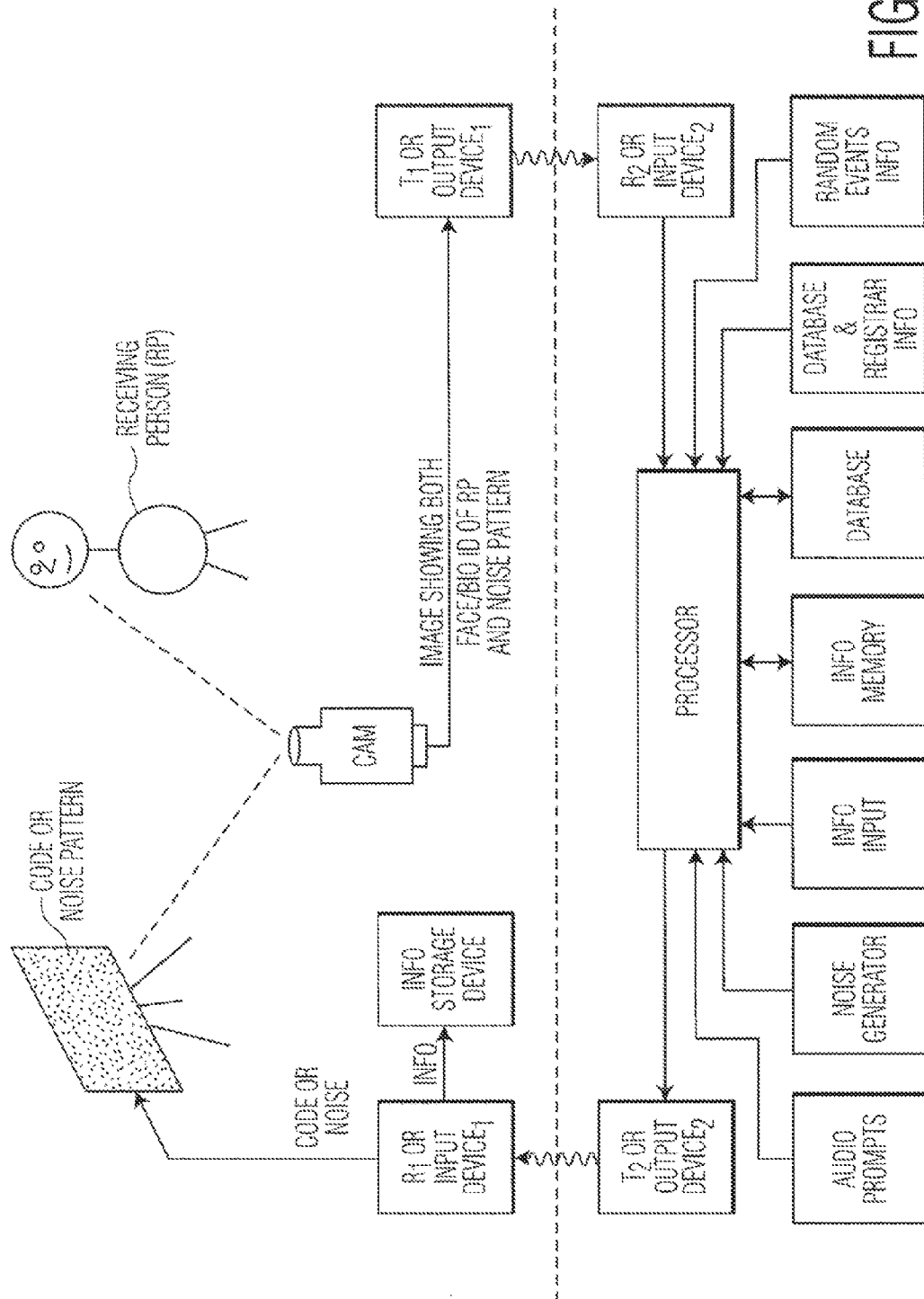


FIG. 17B

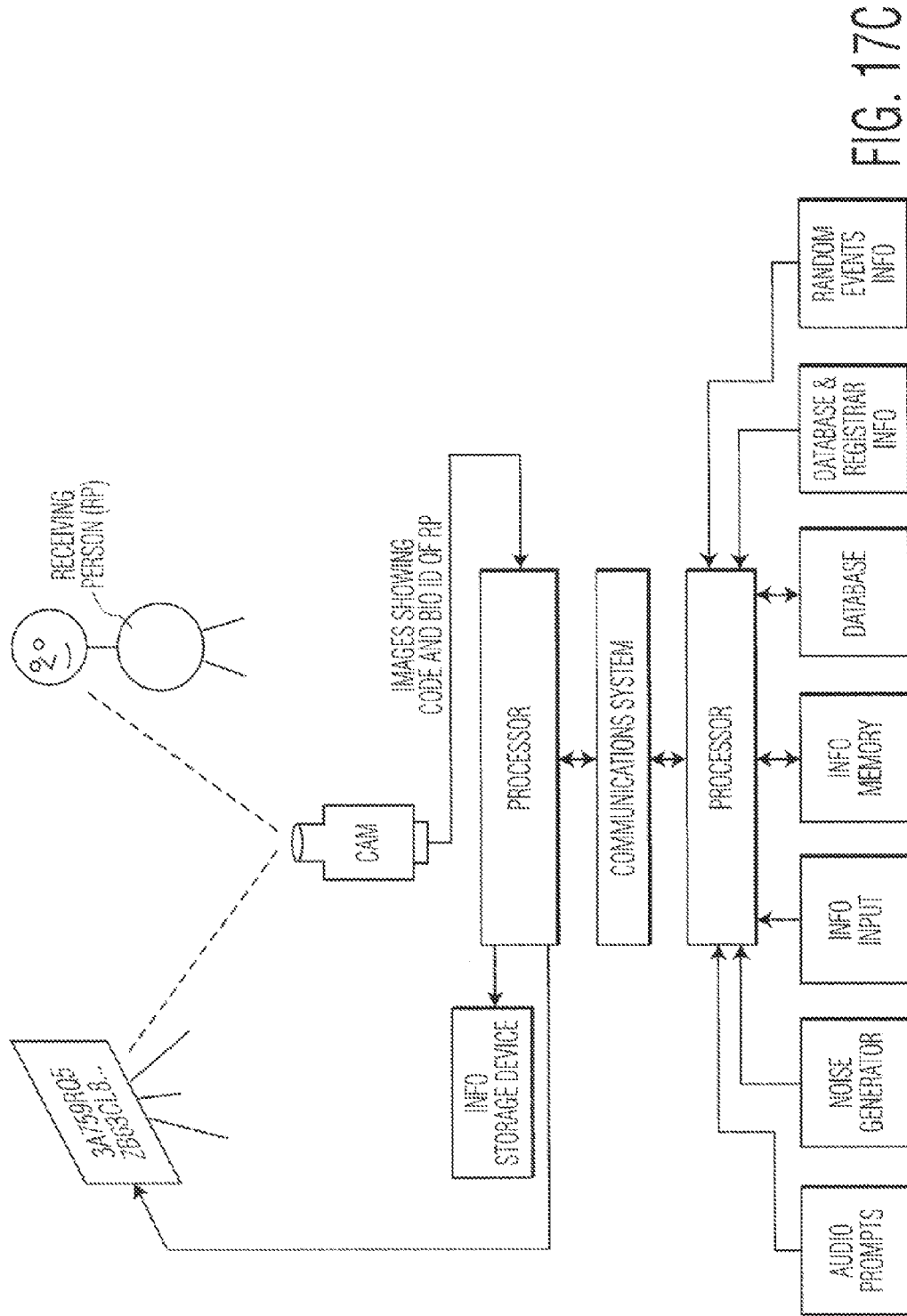


FIG. 17C

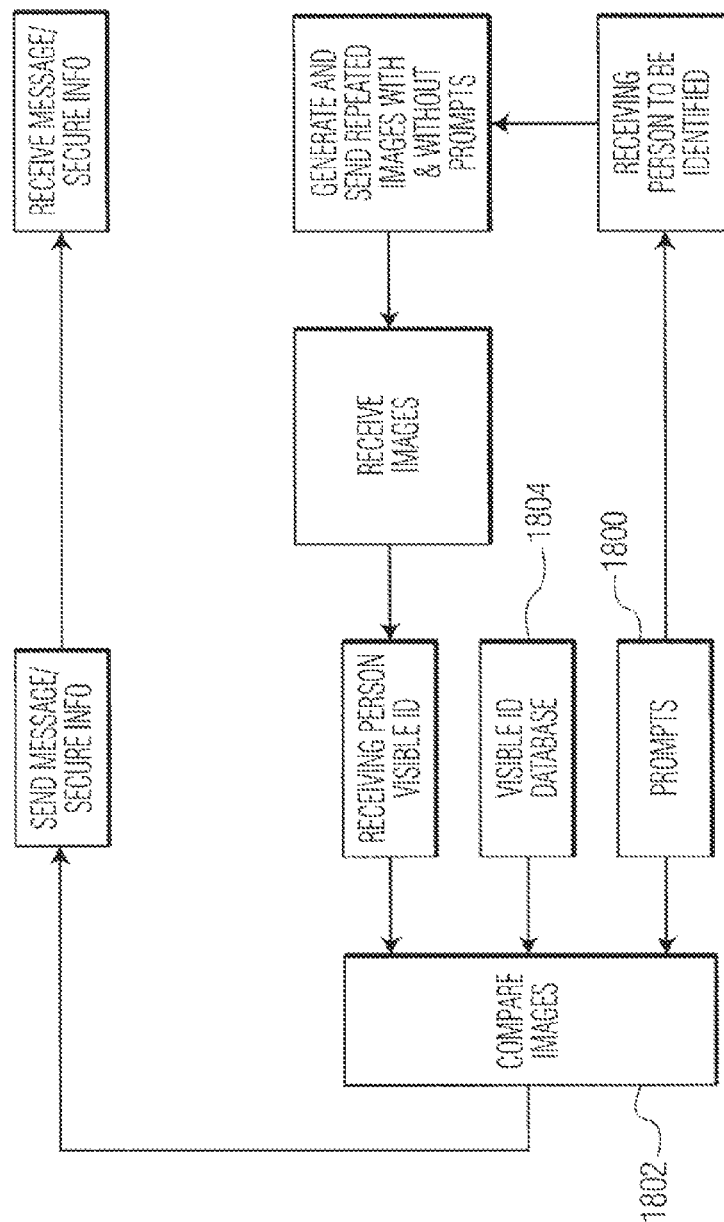


FIG. 18

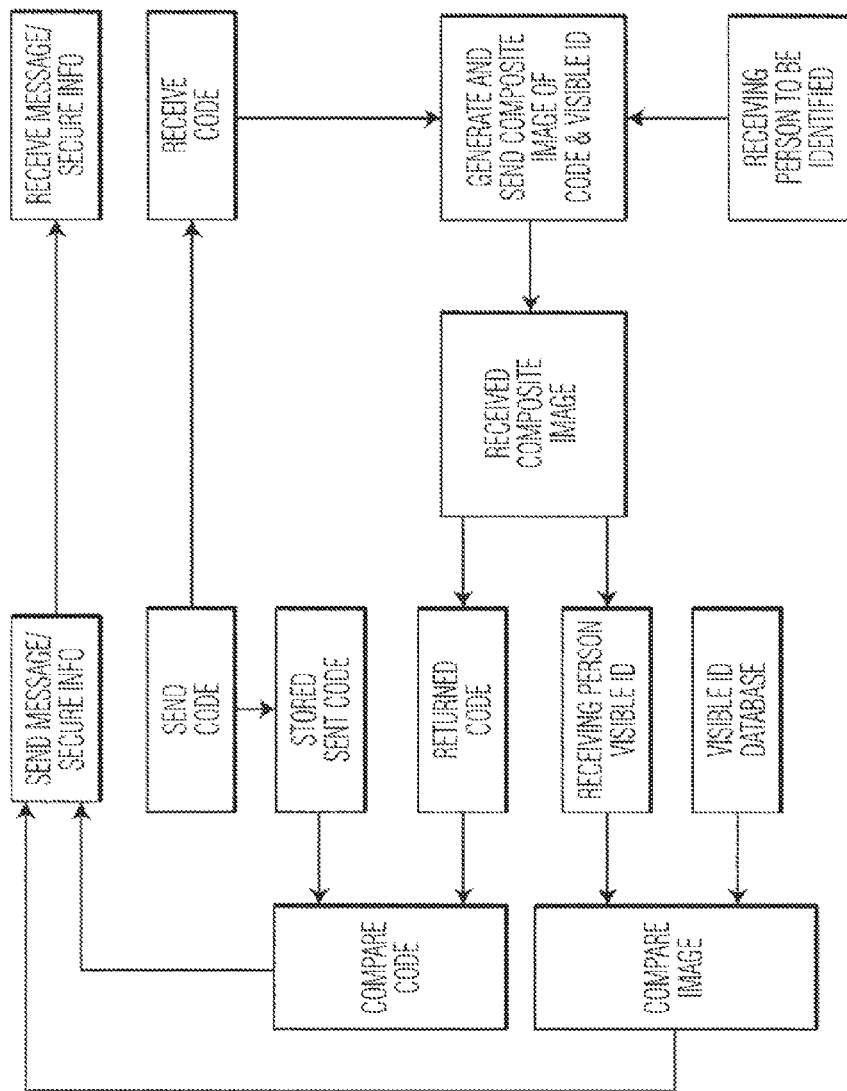


FIG. 19

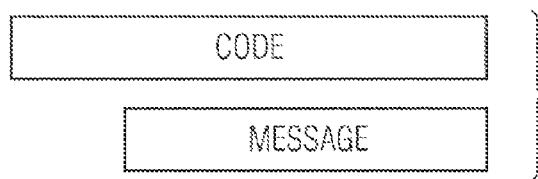


FIG. 20A

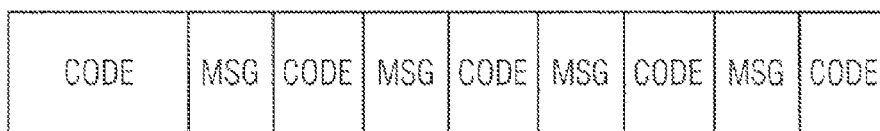
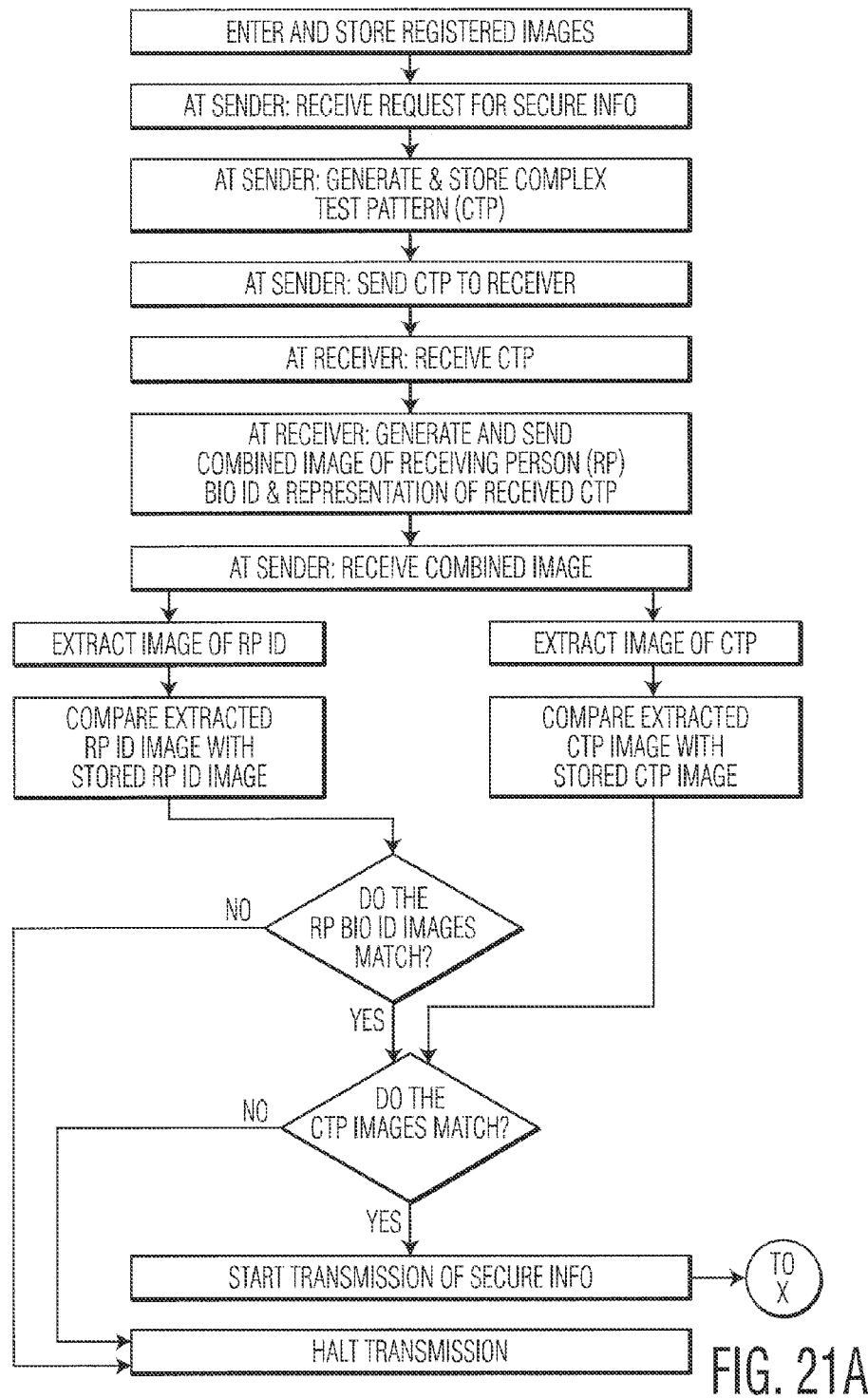


FIG. 20B



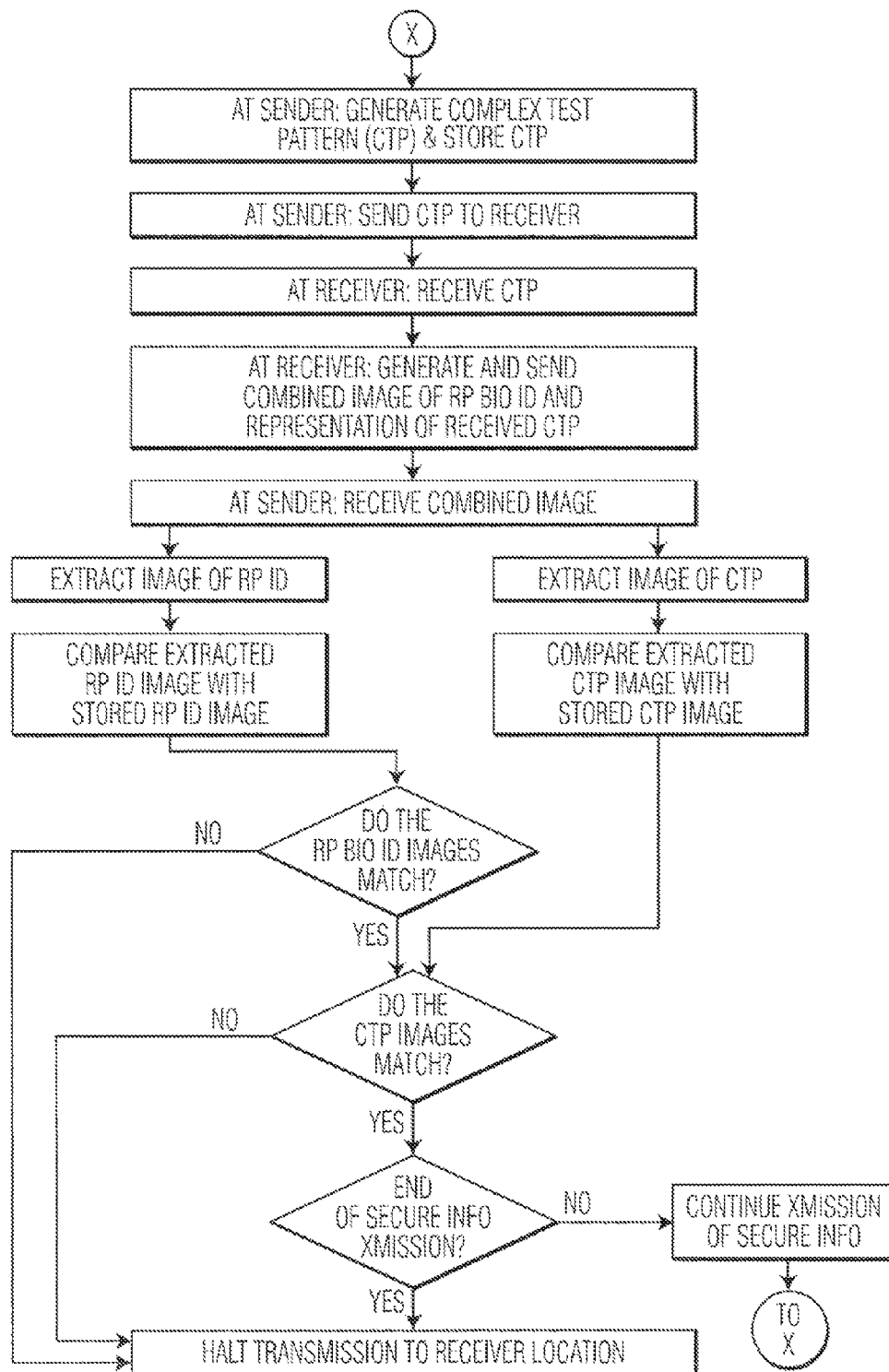


FIG. 21B

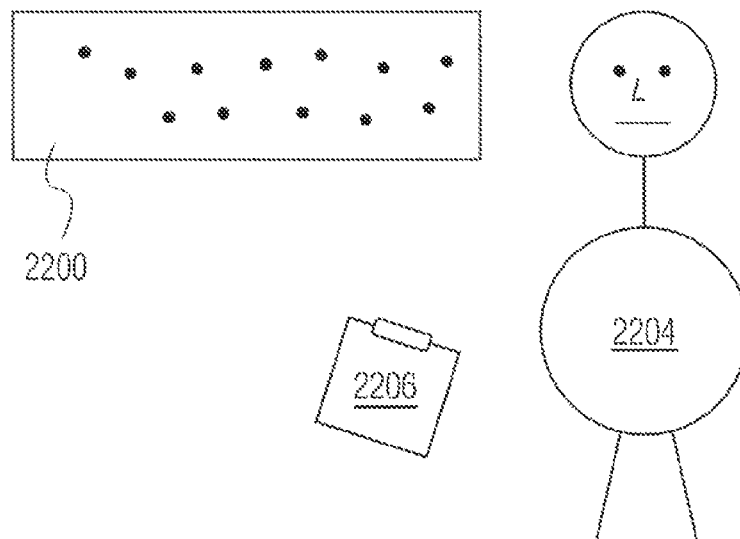


FIG. 22A

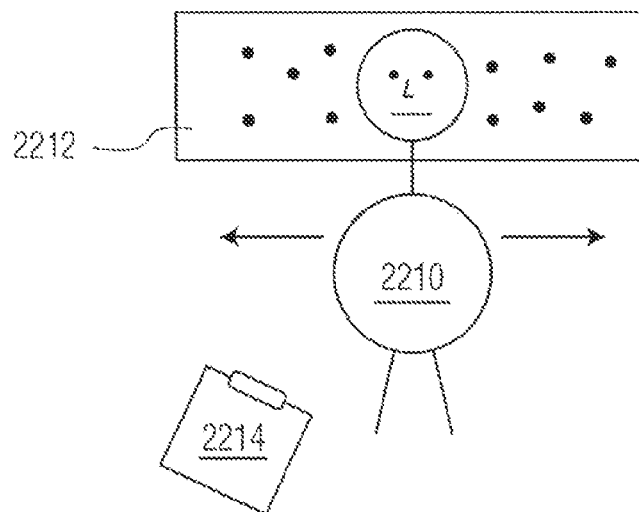


FIG. 22B

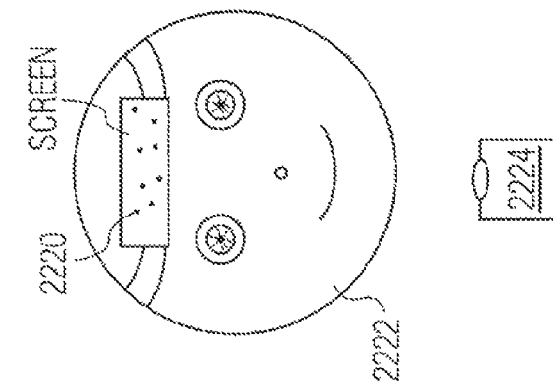


FIG. 22C

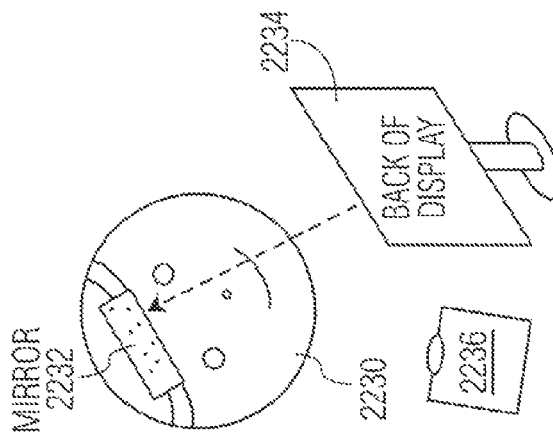


FIG. 22D

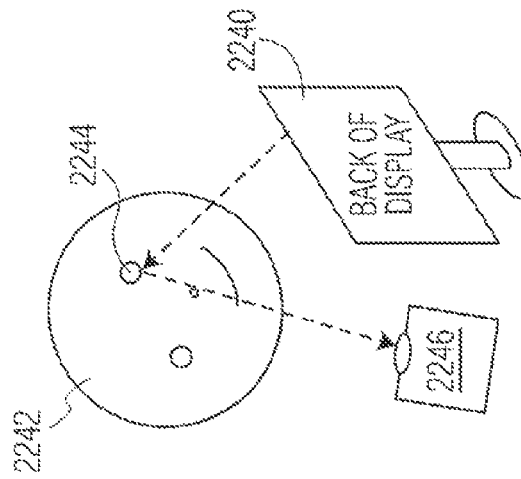
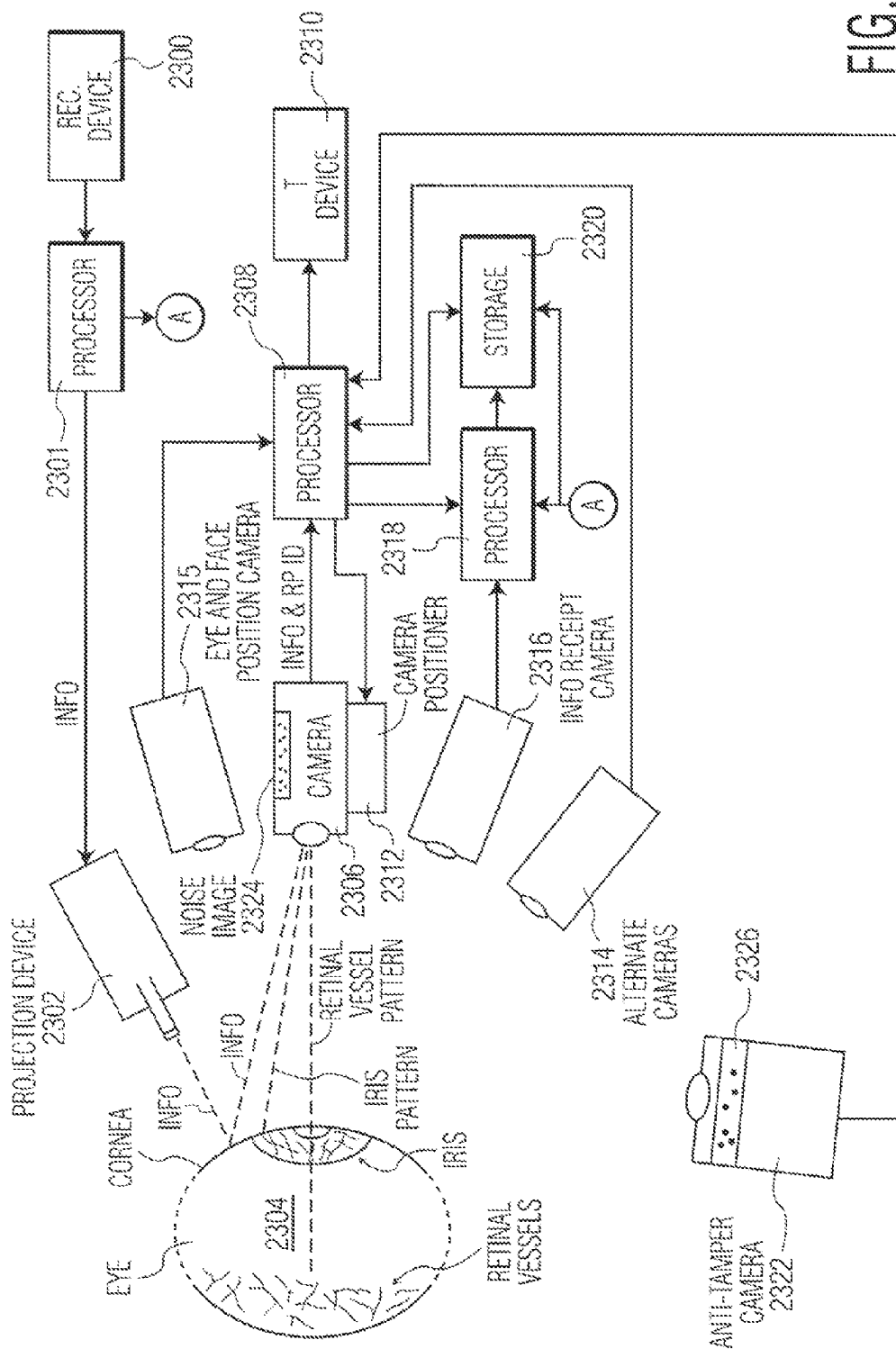


FIG. 22E

25

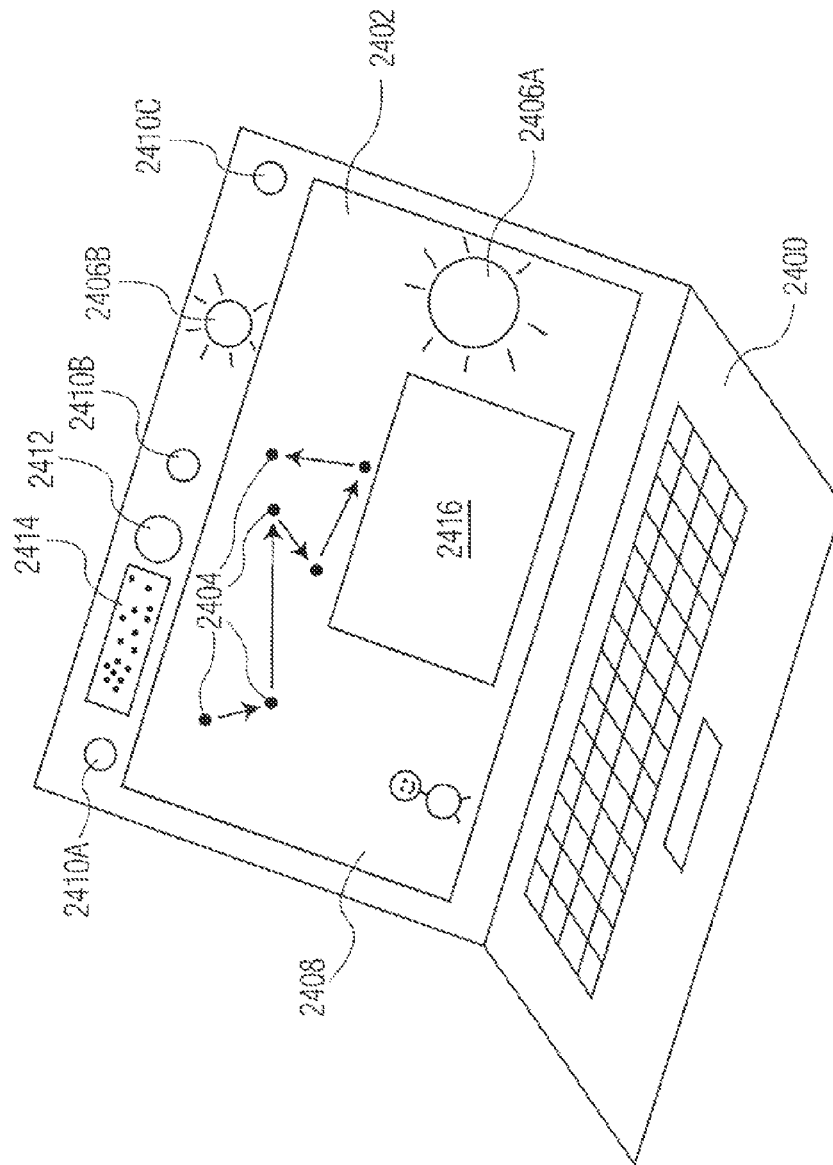


FIG. 24

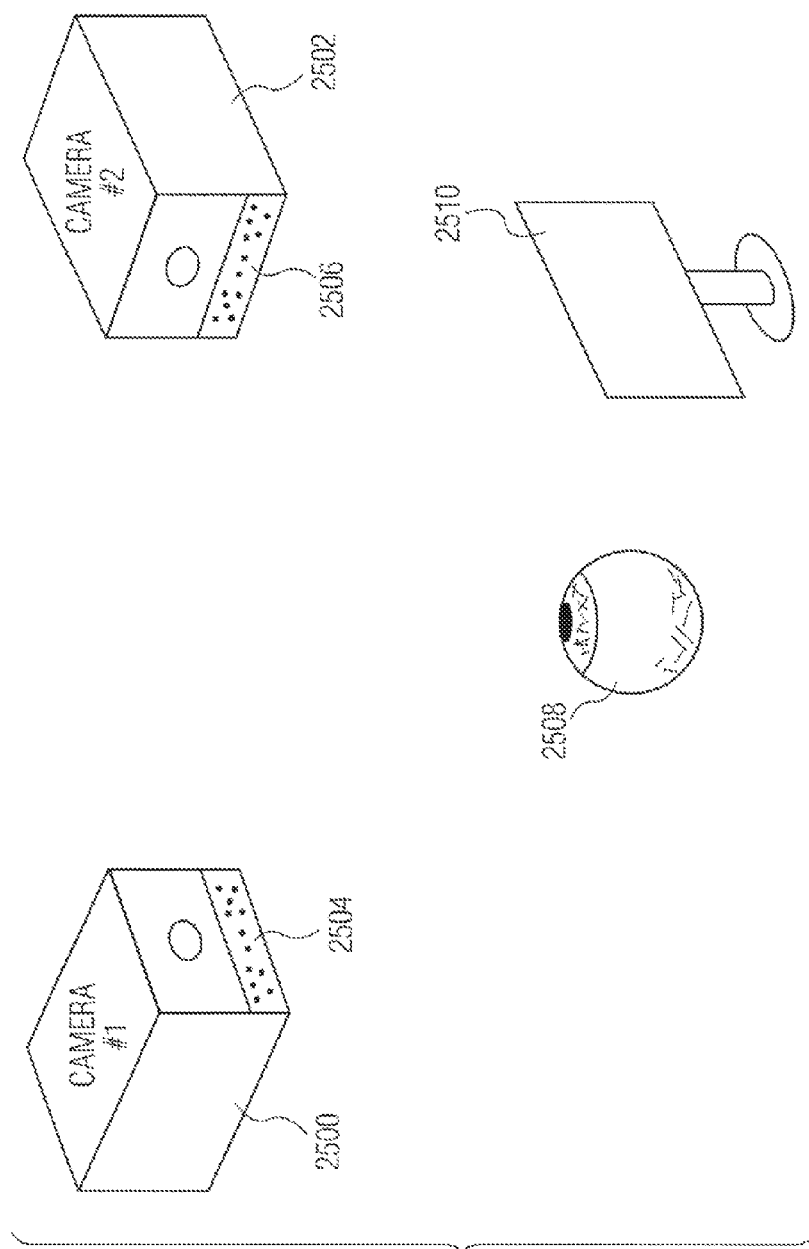


FIG. 25

APPARATUS AND METHOD FOR VERIFYING THE IDENTITY OF AN AUTHOR AND A PERSON RECEIVING INFORMATION

CROSS-REFERENCE TO RELATED APPLICATION

This present application claims the benefit of priority from U.S. Provisional Application Ser. No. 60/934,043, filed Jun. 11, 2007, entitled "APPARATUS AND METHODS FOR REMOTE VOTING AND FOR GOVERNMENT AND CORPORATE SYSTEMS BASED ON REMOTE VOTING," and claims the benefit of priority of the U.S. patent application Ser. No. 12/157,469, filed Jun. 11, 2008 now U.S. Pat. No. 8,233,672, and entitled "APPARATUS AND METHOD FOR VERIFYING THE IDENTITY OF AN AUTHOR", now U.S. Pat. No. 8,233,672. The present application is a continuation-in-part of the aforesaid application.

BACKGROUND OF THE INVENTION

There are a multitude of situations in which it is necessary to be able to document the identity of an individual who produces visually observable material or actions indicating the thoughts or decisions of that individual. Examples of such situations involve an individual who (i) produces written text material, (ii) indicates choices on a touch sensitive screen, (iii) produces alphanumeric entries using a keyboard, (iv) produces artwork, (v) produces a musical work with written material.

SUMMARY OF THE INVENTION

It is a principal object of the present invention to provide a method and apparatus which links the image of an individual (containing identifying features), obtained during a registration process, to the image of an individual author, during his or her act of generating the observable material that reflects the author's thoughts or decisions, thereby to verify the identity of the author with a high degree of confidence.

This object, as well as further objects which will become apparent from the discussion that follows, is achieved, in accordance with the invention, by apparatus which comprises:

(a) a computer database in which are stored an image of a visible identifying feature and other identification data of each of a plurality of registered human individuals;

(b) a computer processor coupled to the database for storing information therein and for accessing selected information therefrom; and

(c) one or more input devices, coupled to the processor and disposed at a local site where an individual is to create writings or make computer entries. The input device(s) includes at least one camera arranged to view and capture a local image of both the identifying feature and at least a portion of a hand of the individual that is engaged in a writing or computer entry process.

The processor is operative to store the local image(s) in said database for later retrieval, and to compare the stored identifying feature of said registered human individuals with the local image(s) of the individual's identifying feature generated during the writing or computer entry process.

By such comparison, the apparatus can thus verify that the identity of the individual who made the writing or computer entry is the same as one of the registered individuals.

Similarly, the aforementioned objects of the present invention are achieved by a method for identifying the writer of a document which comprises the steps of:

(a) storing in a database identifying information for each of a plurality of registered human individuals, this identifying information including both an alphanumeric identifier and an image of a unique, visually observable biologic identifier on a body portion of the respective individual;

(b) capturing local images which include both:

(i) making of at least one of writings and keyboard entries by an individual whose identifying information may be stored in the database; and

(ii) [substantially simultaneous with the capture of (i),] a body portion of said one individual on which is visible said biologic identifier; and

(c) determining whether said individual making the writings and/or keyboard entries is the same as one of the registered individuals whose identifying information is stored in said database, by verifying the substantial equivalence of the local image of the visually observable biological identifier and one said images of the body portion stored in the database.

For a full understanding of the present invention, reference should now be made to the following detailed description of the preferred embodiments of the invention as illustrated in the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a block diagram which illustrates the basic concept underlying one aspect of the present invention.

FIG. 2 shows a flow diagram of the steps followed in a first preferred embodiment of the invention.

FIG. 3 shows a block diagram of the apparatus in said first preferred embodiment of the invention.

FIG. 4 shows a representational diagram of an apparatus for registration and author data and image capture.

FIG. 5 shows another representational diagram of an apparatus for registration and author data and image capture.

FIG. 6 shows a representational diagram of an apparatus which allows for simultaneous viewing of a fingerprint and a keyboard entry.

FIG. 7 shows a representational view of apparatus for simultaneously recording a fingerprint and a choice on a touch sensitive screen, containing three video cameras.

FIG. 8 shows a representational diagram of an apparatus for registration and author data and image capture, with an overhead camera.

FIG. 9 shows a representational diagram of an apparatus for registration and author data and image capture, with an overhead camera and a witness to the process, whose image is also to be captured.

FIG. 10 shows a schematic diagram which illustrates the concept underlying the invention when the image of a witness is captured at the time of the authoring step.

FIG. 11 shows a schematic diagram which illustrates the concept underlying the invention when the image of a registrar is captured at the time of the registration step.

FIG. 12 shows a representational diagram of apparatus for using two identical representations of noise on each of two video screens to document that the recordings of two different cameras have been performed simultaneously.

FIG. 13 shows a flow diagram of the steps followed in an alternate embodiment of the invention.

FIG. 14A is a block diagram, similar to FIG. 1, is a block diagram which illustrates the basic concept underlying another aspect of the present invention.

3

FIG. 14B is a block diagram, similar to FIG. 14A, is a block diagram which illustrates the basic concept underlying yet another aspect of the present invention.

FIG. 15 is a representation of the functional aspect of the human iris.

FIG. 16A is a block diagram of apparatus in a second preferred embodiment of the invention.

FIG. 16B is another block diagram of apparatus in a second preferred embodiment of the invention.

FIG. 16C is a yet another block diagram of apparatus in a second preferred embodiment of the invention.

FIG. 17A is a block diagram of apparatus in a third preferred embodiment of the invention.

FIG. 17B is another block diagram of apparatus in a third preferred embodiment of the invention.

FIG. 17C is yet another block diagram of apparatus in a third preferred embodiment of the invention.

FIG. 18 is a block diagram showing the operation of the apparatus in FIGS. 16A, 16B and 16C.

FIG. 19 is a block diagram showing the operation of the apparatus in FIGS. 17A, 17B and 17C.

FIGS. 20A and 20B are schematic diagrams showing the composition of information sent to a receiving person.

FIGS. 21A and 21B are a flow diagram showing the operation of the apparatus of FIGS. 17A, 17B and 17C.

FIGS. 22A-22D are representational diagrams of apparatus for the simultaneous viewing of code information and an identifying biologic feature.

FIG. 22E is a representational diagram of apparatus for projecting information onto an organ comprising an identified biologic feature, and thence to a camera.

FIG. 23 is another representational diagram of apparatus for projecting information onto an organ comprising an identified biologic feature, and thence to a camera.

FIG. 24 is a representational diagram of a computational device which performs the functions of both the second and the third preferred embodiments of the invention.

FIG. 25 is a representational diagram of an arrangement of cameras for further enhancing the security of both the second and the third preferred embodiments of the invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

The preferred embodiments of the invention will now be described with reference to FIGS. 1-25 of the drawings. Identical elements in the various figures are identified by the same reference numerals.

FIG. 1 shows the conceptual basis of one of the inventions herein. In order to prove who the author of a document is (i.e. to prove the identity of an author of a document), the following three links are established:

- 1) At a registration event: a link between the name of the author (and/or other author identification data) 100 and a video image 102 that identifies the author;
- 2) At an authorship event (the time an author produces an original document): a simultaneously recorded image of a. the document as it is being authored 104, and b. an author image 106, i.e. an image of an identifiable feature of the author; and
- 3) At a verification event (a time when verification of the author identity is confirmed): a determination that the registered author image 102 is substantially identical to the author image 104 which is recorded at the time that the document is authored.

4

The registration event links 100 and 102; the authorship event links 106 and 104; and the verification event links 102 and 106. The net effect, symbolically is:

$$100 \longleftrightarrow 102 \longleftrightarrow 106 \longleftrightarrow 104$$

... thereby establishing that the author is the same person as a registered person.

The document may be one of many types in which there needs to be certainty about the identity of the person who signed it, who authored it, or who indicated his or her thought(s) by one or more writings or keyboard entries. Examples include, but are not limited to

- a) a financial matter which requires a verified signature, such as a check, a loan application, a promissory note, a funds transfer, etc.;
- b) a test, in which the test taker answers questions to demonstrate mastery of certain matters;
- c) an original work—literary, scientific, artistic, musical, etc.
- d) a vote—in a government election, a shareholder matter, etc.
- e) a medical record—including an entry by a physician or nurse, a signature on a “do not resuscitate order”; a signature (by a patient or physician) on a document indicating that informed consent was obtained;
- f) a legal document; such as a contract, a death certificate; a court document; a will; and
- g) a political document such as presidential signature on a legislative bill, a treaty, etc.

The term “author” is intended to include each of the types of person listed in a)-g) hereinabove; and in general is anyone whose identity is to be linked to an observable event. This identity may be a name, a social security number, a medical license number, etc. The observable event generally refers to events which may be seen; But embodiments of the invention which involve only video data, or only audio data (e.g. verification of a speaker or singer) are possible. The events which may be seen include writing using a pen, pencil etc. on a piece of paper, using a virtual pen to write on a touch sensitive screen, selecting a choice from a menu using a touch sensitive screen; using an actual keyboard, and using artistic tools to create a work of art.

FIG. 2 is a flow diagram which parallels the conceptual schematic of FIG. 1. It shows one possible sequence of events by which the 3 aforementioned linkages may occur which link the name of an author to the authored material. First, a registration process 200 ensues, in which a link is established between “ID data” i.e. a person’s name or other identifier (e.g. social security number) and registered images, i.e. a unique visual image of that person (e.g. the face, one or more fingerprints, an iris pattern, a retinal blood vessel pattern, a palm print, signature, etc.). For the registration to occur, a person—the “registrar”—must indicate that they accept the link between the ID data and the person’s image. The process may be similar to an appearance before a notary public, but it could be (i) simpler (e.g. self identification), more (ii) complex (e.g. requiring multiple witnesses, and/or requiring confirmation of one or more biologic identifiers (e.g. fingerprints) from a data bank of such biologic identifiers).

Once the registrar accepts the association between the ID data and the registering person’s image, the data-image pair is stored as a computer file in a database. The image of the data-image pair is then considered to be a registered image. A database may hold:

- a) one or multiple registered images of one person;
- b) registered images of multiple persons (which may include one or more images for each such person).

At block 202, at a time later than the registration process, an author (as defined hereinabove) who has previously registered (by the process indicated hereinabove) and who wishes to have his (male pronoun used hereinbelow without any intention of the choice indicating a preference, limitation, or advantage) identity confirmed, produces a document while simultaneous images are obtained showing:

- (i) the authored data, i.e. the actual writing as it is being produced, or (ii) keystrokes as they are being registered (on either an actual or virtual keyboard); and
- (ii) the author image, i.e. an identifiable biologic feature of the author.

In one preferred embodiment of the invention, the camera which captures the authored data also captures—within the same image—the author image. For example, the camera may be situated so as to capture both the face and the hands of the author, with the portion showing the hands also showing the written material/keystrokes in enough detail to identify its content. Ideally the camera would also show enough of the body region between the face and the hands, so that it was clear that the face and the hands belonged to the same person.

An example (discussed hereinbelow) which clearly demonstrates textual material and author identification in a single image, uses a device which shows author fingerprints, as the author makes keyboard entries.

In another preferred embodiment of the invention, two separate cameras may be used: one to capture the image of the biologic identifier, and one to capture the image of the textual material. The two images may stored as separate files with a secure label for each file, indicating the time and location of each image (to thereby allow for the conclusion that the two were recorded in essentially the same space and time); Alternatively, the two images may be merged into a single file, by techniques known in the art.

At block 204, the author image is compared with either (i) the registered image of the person believed to be the same person as the author; or (ii) some or all of the registered persons, if the identity of the author is either unknown, or substantially uncertain.

At block 206, a determination is made as to whether the author image and a registered image are a match. The definition of a match is further discussed hereinbelow in conjunction with FIG. 3. If a match is present, block 206 leads to block 208, and the authored data and images are labeled as verified, and stored as verified.

FIG. 3 shows an example of apparatus which performs the functions of the invention described herein. Registration video camera 300 allows inputting of images of a biologic identifier such as a face, palm, fingerprint(s), iris or retinal image, to processor 304. A registrar confirms the name or other textual identifier (the ID data) to be associated with the image from 300, and enters the textual identifier through input 302, to processor 304. 304 produces a file which contains both the ID data and the associated video image, and stores the information as a file in registration database 306. 306 contains multiple files (e.g. FILE 1), each of which contains one person's ID data and that person's identifying image (e.g. I₁-NAME₁). 306 is preferably maintained in a highly secure environment. Various means to prevent corruption of the data contained in 306 are known in the art. Maintaining multiple copies of the database in different locations, and requiring a match with two or more copies, each in a different location is one means of enhancing the security of the database.

An author wishing to prove his identity, enters video images of (i) his work as it is being produced by him, and (ii) himself, through input device 308. Video camera 308A is used to produce file 308B, which contains simultaneously recorded author image(s) 307 and authored data image(s) 309.

In an alternate embodiment of the invention, as discussed hereinabove and hereinbelow, there may be more than one camera 308A. 308B is sent to processor 304, which then compares the author image 307 with one or more registered images in database 306. If a match is found, the author data 309—i.e. the signature, composition, document, etc. produced by the author—is then stored as verified writing or keyboard entries in storage apparatus 310. Storage apparatus 310 may be part of 306, or separate from it.

The comparison of the author image and the registered image may be:

- a) performed entirely by processor 304;
- b) performed entirely by optional human 312, who views the two images on display 314;
- c) performed by processor 304, unless the result of the evaluation by 304 results in a state of uncertainty (e.g. if there is a less than good match between the two images); In this case, the task of comparison may be handed off to human 312. Processor 304 may be pre-programmed to indicate the level of goodness of match required to bypass human 312. Processor 304 may use neural networks to facilitate the process of visual comparison.

If the final decision regarding the comparison is made by the processor, the result may be indicated on display 314. Clock 316 allows for time-stamping of images and of comparisons.

The recording by any of the cameras—either during the registration step or the authoring step—may be of a single image or of a sequence of images (e.g. a video or a “movie”). Hereinabove and hereinbelow, “image” is intended to refer to either one of these cases.

FIG. 4 shows a person 400 using one embodiment of the apparatus shown schematically in FIG. 3. The apparatus shown in FIG. 4 may be used for:

- a) registration;
- b) entries by an author who wishes to be a verified author; or
- c) both a) and b).

In the registration process, person 400 may use the apparatus to input two or more unique identifiers simultaneously, in the same image. For example, 400 may sign his name on 402. 402 may represent:

- a) a transparent or semi-transparent surface/paper which allows a signature to be observed and recorded by video camera 404 which is situated below 402;
 - b) a touch sensitive screen with enough resolution to provide a good quality copy of a signature.
- 404 may be used to capture both the signature and
- a) an image of the face, iris or retina of 400; and/or
 - b) an image of one or more fingerprints, or a palm print of 400, visualized through transparent surface 414.

Alternatively, 404 may capture both a fingerprint/palm print and a signature, without capturing the facial/iris/retinal image.

In yet another embodiment of the apparatus used for registration, multiple identifiers may be simultaneously captured in the same image using camera 410 which is situated behind and, if necessary, somewhat to the side of (or above) person 400, and may be pointed at mirror 412. With proper placement of 410 and 412, and proper angulation of 412, camera 410 may visualize both:

7

- a) the signature of person **400** on **402** (which need not be transparent or semi-transparent in this case); and
- b) the face/iris/retina of person **400**.

In yet another alternate embodiment of the registration apparatus, **410** and **404** may both be used to input registration information. Each may be used to input the type of information described hereinabove. The information may be stored:

- a) as two separate files, one for each camera, with each having associated ID data for the registrant, and each confirmed by the registrar (with each file preferably indicating the presence of additional registration information for the same person in another file); or
- b) as a single file.

The information from **404** and **410** may be obtained simultaneously or at separate times.

A simplified form of the registration process would be to enter only a single identifier for **400**, e.g. one of the signature, facial image, etc. The apparatus in FIG. **4** could be used for this purpose. Cameras with other locations (e.g. facing **400**, or above **400**) are also possible. Scanning a signature or fingerprint into processor **304** (of FIG. **3**), using a scanner, as is known in the art (and not shown in the figure) is also possible.

Embodiments of the registration apparatus with more than two cameras are possible. The operating principles parallel those of the two-camera case.

The apparatus shown in FIG. **4** may also be used for the entry of the author image and authored data (**202** in FIG. **2**). In this case, the apparatus is used to simultaneously enter:

- a) written entries or touch sensitive screen based entries; and
- b) at least one visual identifier of the author (e.g. face, signature, fingerprint(s), etc.).

The mode of operation would be the similar to that described hereinabove for the registration process, except that it may be desirable to enter more text (perhaps a lot more text) than just the author's signature. Furthermore, screen **408** may be viewed by camera **410**, and may be used to display either:

- (i) textual material in a document that the author is signing; or
- (ii) a display of what the author is writing on **402** (as observed by camera **404** or another camera (not shown in this figure) which may be placed above **402**). In addition, by angulating mirror **412** so that it shows the author's face, and by properly angulating **408** and **412** and properly positioning **410**, both the face (and/or iris, and/or retina) and the authored data as shown on screen **408**, may be recorded in a single image by **410** (or in each of a series of images recorded by **410**).

FIG. **5** shows a version of the apparatus similar to that shown in FIG. **4**, except that writing surface/touch sensitive screen **402** has been replaced by keyboard **510**. All of the specification in conjunction with FIG. **4** is applicable to the apparatus shown in FIG. **5**. If **510** is a conventional keyboard, then keyboard entries will not be seen from camera **404**; They will be viewable from **410**, with a proper geometric arrangement of **410**, **408** and **412**, as discussed hereinabove.

In an alternate embodiment of the invention, a largely transparent keyboard could be used for **510**. This would facilitate **404** observing the face of **400**.

Furthermore, a keyboard in which the key surfaces are largely transparent—shown in FIG. **6**—would allow simultaneous observation of both:

- a) the author's fingerprint, and
- b) the sequence of selected keystrokes.

In the figure, camera **604** is positioned underneath keyboard **610**, to show both fingerprints and keystrokes in each image.

8

FIG. **7** shows another embodiment of the invention which allows for the simultaneous viewing by a single camera of (i) a biologic identifier of an individual making a choice, and (ii) the choice. In this case, the choice is indicated by the individual by his selection on a touch sensitive screen **702**. In the figure person **700** has the option of indicating either a "yes" or a "no" choice. As shown in the figure, he may indicate "no" by touching touch sensitive box **703**. As he does so, he simultaneously touches fingerprint identification apparatus **706** with another finger. The documentation that the fingerprint recorded by **706** comes from the same individual as the "no" choice may be accomplished by:

- a) a camera **704A** located behind the transparent or semi-transparent touch sensitive screen which records an image which shows each of (i) the finger touching the "no" choice box, **703**, (ii) the contiguous parts of the hand lying between the finger which selects the touch sensitive region and the finger which is the source of the print, and, optionally (iii) the fingerprint itself, viewable through **706**; and

- b) a camera **704B** which is located behind the individual, and records the selection of the "no" choice at the same moment that the fingerprint is visualized by **706**.

In the case of a "yes" choice, the functioning of the apparatus is analogous to its functioning for a "no" choice: The left hand of **700** may be used to simultaneously touch fingerprint identification apparatus **708** and touch box **701** on the touch sensitive screen.

Apparatus similar to that shown in FIG. **7** with two choices other than "yes" or "no" will function in an analogous manner to that described hereinabove. Apparatus with more than two choices will also function in an analogous manner. For example, the right side of screen **200** may contain two or more touch sensitive virtual buttons, each associated with an adjacent fingerprint scanner. In an alternative embodiment of the invention, the hand which is the source of the fingerprint need not be the source of the choice selected on the touch sensitive screen. What is required is that there be visual evidence that the individual who makes the touch sensitive screen selection is the same individual as the one who is the source of the fingerprint; This may be accomplished by camera **704A** alone, or by **704A** in conjunction with either (i) **704B**, (ii) camera **704C**, which faces the individual, or (iii) **704B** and **704C** together.

FIG. **8** shows an example of apparatus similar to that of FIG. **4**, with the addition of ceiling mounted camera **804**. The purpose of the overhead camera is to simultaneously visualize both the face of the author of the writing and the writing itself. The camera need not be ceiling mounted, and could be in a variety of locations. The individual need not be writing, and could be using either a keyboard or a touch sensitive screen.

FIG. **9** shows the same apparatus as that of FIG. **4** with the addition of a witness **901**. In one version, the witness functions as a conventional witness, i.e. he may sign a document indicating that he witnessed the writing by person **900**. In another version, he may, exchange places with **900**, after **900** completes his writing, and the same process (as is described in the specification hereinabove in conjunction with the apparatus shown in FIG. **4**) which records one or more images of **900** may then record one or more images of **901** as he signs indicating his witnessing. In conjunction with the aforementioned two versions, the functioning of camera **904** is analogous to that of **404** in FIG. **4**, and the functioning of camera **910** is analogous to that of **410** in FIG. **4**. Preferably person **901** is a person who has previously undergone the registration process described hereinabove, so that his being an identifiable witness is established. In a preferred embodiment, an identifying image of the witness is captured within the same

camera image as at least one of (i) an identifying image of the writing person **900**, and (ii) the written material. A variety of camera locations and orientations, and, if desired, mirror location(s) and orientations may be used to accomplish this task; Cameras **906** and **910** illustrate two possible camera locations for this task.

FIG. **10** shows a conceptual schematic, analogous to FIG. **1**, which indicates the role of the witness in enhancing the robustness of the identification system. By including within one image:

- (i) the authored material;
- (ii) the author image; and
- (iii) the witness image;

a highly verifiable and very difficult to corrupt/hack, system is the result. If in addition (not shown in the figure), the witness is also a person who has been registered by the same process that the author has, an even greater degree of hardening of the system is the result.

Since the registrar has the role of matching the ID data and the registered images, the robustness of the system will depend on the reliability of the registrar. Various methods of enhancing registrar reliability are possible including having multiple registrars, each of whom reviews the correctness of a paired ID data-registration image set. Yet another method of security enhancement would be to have super-registrars, i.e. people with a high level of security clearance who are responsible for registering ordinary registrars.

Another method of enhancing security during the registration step is shown in FIG. **11**, a schematic analogous to FIGS. **1** and **10**. In this embodiment, the image of a biological identifier of the registrar (obtained with apparatus such as that shown in FIGS. **3** through **6**) and the image of the registered person are merged into either a single file or a single image. Alphanumeric identification of the registrar would be included in the composite file.

FIG. **12** shows a method of demonstrating the simultaneity of recording of two video images on separate cameras. A noise generator **1200** generates a random, highly complex pattern, continuously changing pattern which is identically and simultaneously displayed on video screens **1202** and **1204**. These screens are placed so that they may be recorded by a video camera along with the other material to be recorded by that camera. Thus camera **1206A** simultaneously records both the face of person **1208** and the highly complex, continuously changing pattern on screen **1202**. Camera **1206B** simultaneously records the text material **1210** written by **1208** and the complex video images on **1204** (which are identical to the images on **1202**). Since the task of duplicating the complex and continuously changing pattern of images displayed by **1202** and **1204** would be extremely arduous, it would make attempting to corrupt one of a pair of simultaneously recorded images (e.g. by substituting a different face), extremely difficult or impossible. **1200** may generate any one of a number of forms of very complex pattern including white noise, other noise, or even a repetitive pattern of extreme complexity.

FIG. **13**, analogous to FIG. **2**, shows a flow diagram of another embodiment of the invention, in which the order of registration (block **200** in FIG. **2**) and authorship (block **202** in FIG. **2**) is reversed.

The concept of linking a particular person to a particular body of information has, hereinabove, been considered with respect to providing a strong linkage between provided information and the person providing the information. Hereinbelow, the concept and invention is presented with respect to providing a strong linkage between provided information and the person requesting the information. It will be clear that

such a strong link will be useful for (a) providing secure communications, (b) for preventing access to information stored in a computer memory or other digital device by an inappropriate person, and (c) preventing the modification of information stored in a computer memory or other digital device by an inappropriate person.

FIG. **14A** shows the conceptual basis of an invention which identifies a person requesting to receive information, ("RP") by:

- (a) repeatedly examining a biologic feature of the person and comparing it to information in a database which contains files which comprise
 - (i) information pertaining to the details of the biologic feature of a registered person, the information having been obtained under a plurality of different conditions, and
 - (ii) alphanumeric identification [e.g. name, social security number, date of birth, etc. are also stored in correspondence to the biologic information] of the registered person; and
- (b) providing a prompt which induces a change in the appearance of the biologic identifier.

By providing a prompt which alters the appearance of the identifier, and by repeatedly observing the identifier, the invention provides a far more secure system than the static approach, known in the art, of simply comparing an image of a biologic identifier ("BI") of a person requesting access to a digital system to file images. An example of the static approach is described in U.S. Pat. No. 8,189,096 to Azar.

Defeating the static approach, i.e. causing a computer or communication system protected by the requirement of providing a static image, entails (i) obtaining and storing a BI image, during a process that is perhaps unknown to the person associated with the BI, and (ii) providing the previously stored image of the BI, at a time when information or computer system access is desired by someone who is not the person associated with the BI [i.e. an inappropriate person ("IP")], but who is in possession of and can provide the information contained in the static BI.

The static system becomes harder to defeat if multiple (static) images must be provided to gain access to the system. But it still may be defeatable by an IP, by obtaining a multiplicity of static images of the BI of a person registered to use the system.

In one embodiment of the current invention, advantage is taken of the ability to change the appearance of a BI upon the request of the person or system providing secure information or desiring secure communication. A simple approach is a voluntary request to the RP to perform a motion which results in a change in the appearance of that person's BI. Examples of such changes include a request to turn the RP's face in one direction or another, to wink one eye, to look to the right, left, up, down, etc. (with or without moving the head) or to move a finger containing a fingerprint in a particular way, or a palm containing a palm print or a pattern of blood vessels in a particular way.

Still other requests may involve moving one part of the body containing one BI so that its relationship with another part of the body containing another BI is geometrically altered. The value of such a voluntary prompt is that the nature and timing of the request is entirely under the control of the information source ("IS"), whether the source is a person or a computational device.

Still other requests may be for the RP to follow a moving point or object on a display screen, using apparatus in which the IS controls the trajectory of the point on the screen, while a camera observes the user eye motion, iris image, retinal vein

11

image, image of blood vessels on the surface of the eye, or facial motion. Although the tracking of such a point by the RP would not perfectly match the apparent motion of the point, software methods to compensate, and statistical techniques to assess a match could be applied as are known in the art. Clearly, attempts by an IP to communicate inappropriately with such a system would be extremely difficult, requiring the IP to very quickly provide a sequence of BI images which match a not previously expected pattern of variance. By making the choice and timing of prompts random or pseudo random (e.g. by using a variety of techniques to generate such random information including the digitization of white noise, the use of minutae related to sports information [e.g. number of milliseconds between pitches in an ongoing baseball game], stock market minutae [e.g. ongoing trades and their timing], astronomic information [e.g. solar activity], traffic information minutae [patterns of people walking through Times Square], by electronically generating pseudorandom number patterns), the task of the IP becomes more difficult.

A still greater burden on the inappropriate person attempting to gain access entails the use of prompts resulting in entirely involuntary physiologic actions. One such example is the application of light to the human eye. As shown in FIG. 15, the pupil 1500A-C, an opening in the iris 1502A-C, constricts in response to light in a graded fashion over a certain range, i.e. more light impinging on the eye causes more constriction of the pupil/"enlargement" of the iris, which in turn is mediated by muscular tissue within the iris. This process causes a change the appearance of the iris. Since the iris is a known biologic identifier, the application of light to the eye will produce a change in the observed biologic identification information. Thus any one individual will have nearly limitless possible iris patterns, which can be obtained by a change in the amount of incident light.

In turn, the extent of incident light may be controlled by apparatus at the information source. Prompts can control the light intensity, the wavelength, the spatial placement of the light, the size of the light source, the number of light impulses, the time interval between impulses, the duration of each impulse, etc. Furthermore, the IS may store prompt details and generate an expected iris response for comparison with an observed one. Furthermore, the IS may generate linear and other combinations of iris images stored in a computer database, thereby potentially expanding the database limitlessly. The IS may also adjust the amount of applied light to attempt to match an iris image on file.

In addition, alteration in iris size may be induced by having the RP change focus from a distant object to a near one (which may be presented on a computer or digital device display screen), or vice versa. In addition, dilation of the pupil/constriction of the iris may be induced by a painful stimulus, which may be applied to the RP under remote control via a device attached to the patient (e.g. one which provides a mild electric shock).

A given induced change in iris image, (i.e. the varying biologic identifier), may not always occur identically for a given amount of light. The system administrators and architects will overcome this by either (a) storing a variety of responses to each prompt, obtained during a registration period for the person who is to be an authorized user of the system, (b) utilizing linear or other combinations of previously observed responses by a particular user, or (c) by utilizing neural networks to learn the patterns of authorized system users.

The pupil/iris changes, in turn, will change the appearance of another BI, the observed pattern of retinal blood vessels. A constricted pupil narrows the area of retinal surface (and

12

vascular pattern) available for view, while a dilated pupil has the opposite effect. Thus another embodiment of the invention entails RP identification using retinal vessels as the BI, with prompts causing a change in iris/pupil geometry which changes the viewable retinal field.

The aforementioned involuntary changes in the appearance of the BIs caused by IS prompts in an essentially unpredictable manner would create a situation that would be extremely difficult for an IP to defeat.

Referring again to FIG. 14A, registered images of the BI 1400, each linked to alphanumeric identification data 1402 of a person authorized to access the system ("AP") are stored in a database. If a RP requests access to the system, information from the system, or the ability to communicate with a person using the system, prompts are sent 1404, received 1406 and applied such that upon interacting with RP 1408, the prompts alter the BI. Images of the RP 1408 are repeatedly compared with registered images 1400, to determine if the RP is an AP. If the RP is determined to be an AP, as a result of repeated biologic ID match during the application of one or more prompts, then information 1410 may be exchanged with, or sent to the requesting person.

FIG. 16A shows one embodiment of apparatus for the aforementioned prompt-based security system. AP identifying information is stored in and accessed from database 1600 by processor 1602. Prompts may be generated in a variety of ways, as indicated hereinabove, including the digitization of white or other noise input from generator 1606, the digitization of information related to random or almost-random events inputted at 1608, by a random or pseudorandom number generation program which runs on processor 1602, or by inputted audio prompts 1610. The processor outputs a signal to a prompt generating device, which may be a screen which displays digital information 1612, a sound producing device 1614, a light producing device or a pain producing device. Camera 1616 is oriented to view the biologic identifier (e.g. iris pattern, retinal veins, etc.) of RP 1618 in detail. 1616 supplies data representing repeated images of the BI of the RP to processor 1602. 1602 compares the received data representing these images to the data stored in database 1600. The results of the comparison may be indicated by either (a) a numeric or graphic indication of the degree of correspondence between the 1618-derived images and the database images, (b) an indication that a threshold has been exceeded for declaring a match between the RP and an AP, and/or (c) the allowance of access to information in computer memory 1620. Information is input to 1620 by input device 1622. Information obtained, following the allowance of access, may be stored in information storage device 1626.

As indicated hereinabove, the certification that AP information stored in 1600 is indeed correct may be accomplished by utilizing a registrar, i.e. a registration person who is authorized to input information to 1600. This input occurs via input device 1624, which may also input alphanumeric and/or biologic identification information pertaining to the registrar.

Whereas for the embodiment shown in FIG. 16A the connections between (i) processor 1602 and (ii) each of camera 1616 and prompt device 1612 comprise a wired connection or a series of wired connections, FIG. 16B shows embodiment of the invention in which camera 1642 and prompt producing device 1644 are in communication with processor 1646 by wireless means. The link between 1646 to 1644 is via transmitting device or output device 1648 and receiving device or input device 1650. The link from processor 1646 to camera 1642 is via transmitting device or output device 1652 and receiving device or input device 1654. 1648 and 1654 may comprise a single transmitting and receiving device. 1652 and

13

1650 may comprise a single transmitting and receiving device. A wide variety of such communication devices and methods will be known to those skilled in the art. Combinations of wired and wireless links for the system, which embody features of each of FIGS. **16A** and **16B** are possible as well.

Communication between (i) the processor **1646** and (ii) each of camera **1642** and prompt device **1644** may be by a public or private telephone network, the internet, a private digital or analog communication network, radiofrequency communication (including the microwave portion of the spectrum, and Bluetooth communication), satellite-based communication, light communication (including infrared and ultraviolet), communication by modulated magnetic fields, and communication by sound, ultrasound, or subsonic longitudinal wave modulation means.

RP **1640**, camera **1642** and prompt device **1644** may be situated in a location which is different, and possibly remote from processor **1646**, and its associated input devices and memory devices. Such a separation between the corresponding elements of FIG. **16A** is also possible.

Each of the remaining elements in FIG. **16B** is functionally the same as the corresponding element in FIG. **16A**, described hereinabove.

FIG. **16C** is functionally similar to **16B**, except the input/output—transmitting/receiving devices have been replaced by a communication system. In addition, each of camera **1674**, prompt device **1678** and storage device **1680** are linked to the system via a second processor **1672**.

As is known in the art, each processor **1670** (which is analogous to processor **1646** in FIG. **16B**) and **1672** will be linked to interface elements, to facilitate the exchange of information with the system. The methods and means of communicating through the system are those stated in conjunction with FIG. **16B**. The relative locations of each processor and its linked elements (e.g. camera **1674**, in the case of processor **1672**), are also conceptually parallel to the situation described in conjunction with FIG. **16B**.

Although FIGS. **16A**, **16B** and **16C** each show different means of linking the prompt producing and image analyzing processor (e.g. **1602**, **1646** and **1670**) to the respective prompt producing device and camera, these figures all pertain to a common invention.

FIG. **16C** also shows an audio output device **1682** for delivering audio prompts from input device **1686**. It also shows a pain producing device **1684**, attached to the body of the RP, which may provide a shock, heat or other noxious stimulus.

FIG. **18** shows a block diagram indicating the function of the prompt-based embodiment of the invention. It has been fully described in conjunction with the specification of FIGS. **14A**, and **16A-C**. The nature and timing of prompts **1800** may be utilized for comparing images **1802**, since clearly it would be advantageous for the processor to indicate a proper correspondence between prompt and observed change in BI. For example, the observation of a pupil which dilates in response to a light stimulus, even if associated with observed iris images before and after the stimulus which match those in the database, would call into question the veracity of the identification.

Visible ID database **1804** may also contain biologic ID images which show a body part from a variety of vantage points and angles.

Another approach to further increasing the security and accuracy of identification of a user, and the location of the user of the system is shown in each of FIGS. **14B**, **17A-C** and **19**. Referring to FIG. **17A**, the apparatus differs from corre-

14

sponding FIG. **16A**, in that processor **1700** is operative to generate a code and to produce a signal which causes display screen **1702** to display a visual representation of the code. Camera **1704** is situated to view both screen **1702** and the BI of RP **1706**, to produce a composite image containing both the BI and the screen image of the code. Processor **1700**, on receipt of the composite image extracts each of the code image and the RP image. It compares the code image with a stored version of the sent code, and it compares the Bio ID image with data in its database. It then can (i) indicate a numerical or graphical presentation of the extent of match of each of the two composite image components, (ii) indicate whether each or both has met or exceeded a threshold deemed to be satisfactory, and/or (iii) allow the passage of information to storage device **1708** from information memory **1710**.

It is to be understood that each step in the passage of the information reflected by the code may involve a degree of distortion/degradation of the information. The conversion of the information from digital signal to visual display is one such step, as is the conversion of the screen information to a camera image, and the conversion of the camera image to a camera signal. Further losses of integrity may occur during each limb of signal transmission from and to the processor. Thus the analysis of the received code by the processor, and its comparison with the sent code will result in a less than perfect match even when system integrity is uncompromised. Algorithms for assessing the goodness of fit of the received version of the code information to the sent version will be apparent to those skilled in the art.

The difficulty of having an inappropriate person gain access to processor **1700** is enhanced by including the code component in the composite image: Gaining such access would require the IP to be able to reproduce the BI and reproduce the image of the code, and to do so within a single image. The difficulty of such reproduction is enhanced by rapidly changing the code. Each of the elements (the noise generator, the random outside events information and the processor itself) utilized to generate random and pseudorandom variations discussed in conjunction with FIG. **16A**, is utilized in FIG. **17A** to generate such variations in the code.

This variation may utilize either a single image of biologic ID/code image or repeated ones. In addition, a prompt producing device and activation means (not shown in the figure), could be added to further augment the degree of security.

Each of the remaining elements of FIG. **17A** is analogous to the respective element in FIG. **16A**.

FIG. **17B** is analogous to FIG. **16B**, in that both show a wireless means for communicating between (i) the processor, and (ii) the items in the vicinity of the RP (which in the case of FIG. **17B** are the camera and the code display screen).

FIG. **17C** is analogous to FIG. **16C**. It shows the embodiment of the invention with composite images of both code and BI, and a communication system linking the first processor with camera, information storage device and screen via a second processor.

FIG. **19** shows a functional block diagram of the operation of the apparatus in FIGS. **17A-17C**. The block diagram is analogous to that of FIG. **18**, for the prompts version of the invention.

FIG. **14B** shows the conceptual basis of the composite image in the visualized code version of the invention, and is analogous to FIG. **14A** for the prompts version of the invention. Sent code **1440**, arrives at the RP site as received code **1442** and is incorporated into composite image **1446** and is extracted from the image as returned code **1444**. The information in **1444** is compared with that of **1440**, to assess the extent of match. In addition, the extracted bio ID image **1448**

15

is compared to the database image **1450**. If the comparisons are satisfactory, information may be received **1452** by the RP.

FIGS. **20A** and **20B** show schematic representations of how code and message may be arrayed, for versions of the invention which use the code matching procedure. In both figures, the transmission of code precedes the transmission of a message or information containing secure information. In FIG. **20A**, once a period of code transmission indicates a satisfactory information exchange, the message and code are each transmitted in parallel fashion. Any interruption in code match results in interruption of the message. In FIG. **20B**, the process is incremental: a code segment is followed by a message segment; then the process repeats. A failure to match properly at any point results in interruption of the message.

A flow diagram of the algorithm which embodies the schematics of FIGS. **20A** and **20B** is shown in FIGS. **21A** and **21B**.

FIGS. **22A-22D** show various configurations for merging the screen which shows a representation of the code, and a visible biologically unique feature of a person requesting receipt of information. In FIG. **22A**, screen **2200** (in which the code representation is indicated by an array of randomly placed dots) is next to RP **2204**. The iris, retinal vessels, face or other body part of **2204** is imaged with screen **2200** by camera **2206**. In FIG. **22B**, RP **2210** is situated in front of screen **2212**. The scene is imaged by camera **2214**. RP **2210** may receive prompts instructing the RP to move to the right or left, to move closer to or further away from **2212**, etc. Having information about the spatial relationship between the camera **2214** and each of the RP and the screen allows the processor to calculate which portions of the imaged code become obscured or visible as the RP carries out the prompt instructions.

Yet another technique for merging the code screen and the BI is shown in FIG. **22C**. Screen **2220** is wearable, attached to the head of RP **2222** by a headband. Camera **2224**, pointed at the face of the RP can image the screen and either the iris, retinal vessels, face, skin quality, etc. of the RP.

FIG. **22D** shows RP **2232** wearing a reflective surface—e.g. a mirrored item—above the eyes. The surface reflects the contents of screen **2234**, on which the code would be displayed (code not seen because the back of screen faces the reader). Camera **2236**, like camera **2234** in FIG. **22C** images both the BI and the screen contents.

In the aforementioned detailed description of each of FIGS. **14B**, **17A-C**, **19**, **20**, **21A-B** and **22A-D**, the screen contents have been stated to be a representation of a code.

However, an embodiment of the invention in which the screen contents are a message to the RP is also possible. Yet another variation is an embodiment in which the screen contents comprise a mixture of a message and a code. In some if not many cases, these arrangements will be considered to be less desirable because the verification process would require two-way transmission of the message: i.e. (a) from the processor to the screen, and (b) back to the processor as part of the composite image.

Although a two way version of the invention is possible, in which two people communicate each having a respective RP camera and display screen (or RP camera and prompt producing device), and each having a respective processor for analysis of the aforementioned matches, the two way transmission would increase the chance of interception and/or diversion of the message.

An additional means of security entails projecting a code image onto a reflective portion of the eye of the RP, and then imaging the reflected image. This is shown in FIG. **22E**, in which display device **2240** projects a code image onto the eye

16

2244 of RP **2242**, which is then imaged by camera **2246**. This allows for especially close linkage of BI ID and code image, since both concern the eye of the RP.

FIG. **23** shows a detailed version of this embodiment of the invention. Projection device **2302** receives coded information from receiving device **2300** which is projected onto eye **2304**. Camera **2306** images the eye and BI (e.g. retinal vessel pattern and/or iris pattern) and sends the composite image via processor **2308** and transmitting device **2310** back to the processor which was the source of the code (e.g. **1700** in FIG. **17A**) for analysis. Thus the code display screen is, effectively, the reflective surface of the eye. In order to deal with the fact that making such an arrangement functional requires that the eye be positioned so that the reflected image falls on the imaging device of camera **2306**, various enhancements include:

(a) camera positioner **2312**, which receives positioning signals from processor **2308**. Camera **2315**, which views eye and face position provides positioning information for **2308**, as does the image viewed by **2306**;

(b) the addition of alternate cameras, such as camera **2314**, which serve the same function as camera **2306**, but are situated in alternate locations;

(c) (not shown in the figure) a positioning device similar to **2312**, electrically linked to processor **2308** and mechanically linked to projection device **2302**.

In addition, prompts directed to the RP indicating instructions for orienting the face and eyes will enhance the success of this approach. Once such apparatus is shown in FIG. **24**, in which a moving dot on screen **2402** indicates a preferred direction of gaze for the RP. The information for the dot position is supplied by processor **2308** of FIG. **23**, and is updated on a high frequency basis. Many other arrangements for stabilization of the geometric arrangement of projection device, RP eye and cameras will be obvious to those skilled in the art.

Referring again to figure FIG. **23**, message transmission in this embodiment of the invention also entails bouncing a light beam off of the eye, for detection by info receipt camera **2316** and storage (via processor **2318**) in **2320**; alternatively the message route could be **2306**→**2308**→**2318**→**2320** or **2306**→**2308**→**2320** or **2301**→“A”→**2318**→**2320** or **2301**→“A”→**2320**. Variations in the route of information entry to **2320**, and in the arrangement and number of cameras and processors will be apparent to those skilled in the art. Although three processors are shown in the figure, designs with a smaller or larger number of processors are possible. In each variation, the critical “loop” which allows the sender of information to properly identify the receiver of the information includes **2300**→**2302**→**2304**→**2306**→**2310**.

Camera **2322**, referred to as an anti-tamper camera is configured to view one or more of the elements in the figure to prevent tampering with them. It can also view a screen **2324** on the housing of camera **2306**, which displays a code (either the same of a different code as reflected off of the eye), for verifying the identity of camera **2306**. Alternatively, or in addition, camera **2306** can view a code on screen **2326** attached to the housing of the anti-tamper camera. The code displayed by **2326** may be the same as either of the aforementioned codes or different.

Referring again to FIG. **24**, the laptop **2400** is configured to provide many of the features presented hereinabove. These include multiple cameras **2410A-C**, a light source for pupil/iris manipulation which is either screen based (**2406A**) or discrete (**2406B**), a projection device **2412** analogous to that of FIGS. **22E** and **23**, element **2408** indicating a prompt for the voluntary motion discussed hereinabove, and a code dis-

17

play device **2414**, for use in conjunction with the mirror apparatus of FIG. **22E**. (Alternatively, the mirror device could be utilized with the code displayed on screen **2402**.) The secure message for a verified RP would be either displayed on **2402** e.g. within area **2416**, stored in a memory device of **2400**, stored in an external memory device, or a combination of these.

FIG. **25** shows an embodiment of the multicamera security system, in which each of two cameras **2500** and **2502** observes (a) the other camera and (b) at least one of (i) the bio ID **2508**, and (ii) the code display screen **2510**. At least one camera also comprises a respective code display screen **2504** and **2506**, for verifying the identity of the camera. The code representation displayed by each of **2504**, **2506** and **2510** may be the same or different.

The inventions described herein are applicable for preventing an inappropriate person from gaining access to secret or classified information in a remote computer memory; Gaining access includes copying the information and corrupting the information.

There has thus been shown and described a novel system for verifying the identity of an author and for verifying the identity of a person receiving information or using a computer system, which fulfills all the objects and advantages sought therefor. Many changes, modifications, variations and other uses and applications of the subject invention will, however, become apparent to those skilled in the art after considering this specification and the accompanying drawings which disclose the preferred embodiments thereof. All such changes, modifications, variations and other uses and applications which do not depart from the spirit and scope of the invention are deemed to be covered by the invention, which is to be limited only by the claims which follow.

What is claimed is:

1. Apparatus for verifying the presence of a particular human individual at a given location by altering and repeatedly assessing details of an iris of an eye of said human individual, said apparatus comprising, in combination:

- (a) a computer database in which are stored data representing a plurality of images of an iris and other identification data pertaining to each of at least one registered human individual ("RHI"), wherein each of said images is acquired during a different physiologic state of said RHI, each said state influencing said image of said iris;
- (b) a first processor coupled to the database for accessing selected information from the database and for producing at least one prompt signal;
- (c) at least one first camera arranged
 - (1) to view an iris of a putative human individual ("PHI"), and
 - (2) to generate a plurality of test images of said iris of said PHI for transmission to said first processor;
- (d) a prompt producing device, for producing at least one prompt in response to said at least one prompt signal received from said first processor, for inducing at least one involuntary anatomic change in said iris of said PHI;

wherein said first processor is operative to:

- (1) generate said at least one prompt signal for transmission to said prompt producing device, and thereafter generate at least one representation of at least one post-prompt test image of said iris; and
- (2) compare:
 - (a) data representing (i) at least one of said at least one post-prompt test image, and (ii) at least one other

18

test image of said iris of said PHI received from said at least one first camera,

with

- (b) data representing said stored images of the iris of said at least one RHI;

to verify the identity of the PHI;

thereby to verify that the PHI is the same individual as one of said at least one RHI by assessing said PHI iris during a plurality of physiologic states, or to determine that the PHI is not the same individual as any one of said at least one RHI.

2. The apparatus defined in claim 1, wherein

- (a) said first processor is coupled to (1) each of said at least one first camera and (2) said prompt producing device; and
- (b) each of said first camera, said prompt producing device, said first processor and said computer database is situated at a common location.

3. The apparatus defined in claim 1, wherein said first camera and said prompt producing device are situated at a remote location from said computer database and said first processor, and wherein said apparatus further comprises

- (a) a first transmitting and receiving ("T/R") device, coupled to said first processor, for transmitting said at least one prompt signal to said prompt producing device and for receiving said successive test images from said at least one first camera; and
- (b) a second T/R device, for communication with said first T/R device, said second T/R device coupled to
 - (1) said prompt producing device for receiving said at least one prompt signal, and to
 - (2) said at least one first camera, for transmitting said successive test images;

wherein

- (a) said first processor is further operative to cause said first T/R device to transmit said at least one prompt signal, and to process said received test images;
- (b) said first processor and said computer database are situated at a first location; and
- (c) said second processor, said at least one first camera, and said prompt producing device are situated at a second location.

4. The apparatus defined in claim 1, further comprising:

- (a) a second processor, coupled to each of said at least one first camera and said prompt producing device; and
- (b) a communication system, coupled to each of said first processor and said second processor, for exchanging of signals between said first and said second processors;

wherein

- (a) said second processor is operative to transmit said successive test images to said first processor via said communication system;
- (b) said first processor is operative to transmit said prompt signal to said prompt producing device via said communication system;
- (c) said first processor and said computer database are situated in a first location; and
- (d) said second processor, said at least one first camera, and said prompt producing device are situated at a second location.

5. The apparatus defined in claim 1, further comprising an additional prompt producing device, for communicating to said PHI a request to perform a voluntary anatomic change in an identifying feature, in response to at least one additional prompt signal received from said first processor;

19

wherein said first processor is further operative to generate said additional prompt signal;
thereby to prompt an action under the conscious control of said PHI.

6. The apparatus defined in claim 1, wherein said processor compares said successive test images with those stored images of the identifying feature that include the anatomic change expected to be caused by said prompt.

7. The apparatus defined in claim 1, wherein said computer database further comprises labeling information indicating at least one characteristic of said prompt.

8. The apparatus defined in claim 1, wherein said computer database further comprises labeling information indicating the conditions under which a RHI image was obtained.

9. The apparatus defined in claim 1, wherein

(i) said prompt producing device is a light source configured to generate light in response to said at least one prompt signal, which impinges on said PHI iris thereby to induce said involuntary anatomic change in said PHI iris; and

(ii) said first processor is further operative to cause said prompt producing device to generate said light by generating said at least one prompt signal;

whereby said first processor is operative to compare a plurality of viewed images of said PHI iris, obtained under different lighting conditions, with a plurality of stored RHI iris images;

thereby to verify that said PHI is or is not the same individual as said RHI.

10. The apparatus defined in claim 9, wherein said first processor is further operative to assess whether an image of said PHI iris under a given lighting condition corresponds to a stored image of the iris of said RHI for the given lighting condition;

thereby to determine if the observed anatomic change is appropriate for the lighting condition.

11. The apparatus defined in claim 9, wherein

(i) said database is further operative to store information indicating the amount of incident light at the time a given RHI image of said iris was obtained;

(ii) said first processor is operative to cause said prompt producing device to produce the same amount of light as the amount of incident light at the time said given RHI image of said iris was obtained, resulting in the generation of a respective PHI test image by said at least one first camera, and

(iii) said first processor is operative to compare said respective PHI test image with the given RHI image, with both images obtained with substantially the same amount of incident light.

12. The apparatus defined in claim 9, wherein said first processor is operative to cause said prompt producing device to vary the amount of light produced, and to determine if at least one of said PHI test images matches a stored RHI image; thereby to determine if any lighting condition causes the PHI image to match a RHI image.

13. The apparatus defined in claim 9, wherein said processor is further operative to generate calculated RHI images from at least one of said stored RHI images, and to compare said PHI test images with both said stored and said calculated PHI images.

14. The apparatus of claim 9, wherein

(i) said light source is operative to provide light with a plurality of different light intensities, and

(ii) said prompt signal causes said light source to provide the light intensity specified by said signal.

20

15. The apparatus defined in claim 9, wherein

(i) said light source comprises a plurality of light-emitting elements, and

(ii) said first processor is operative to select the number of illuminated light-emitting elements, thereby to determine (i) the amount of iris illumination and (ii) the extent of alteration in said iris opening size.

16. The apparatus defined in claim 9,

(i) said light source comprises a plurality of light-emitting elements, each operative to emit a different wavelength of light, and

(ii) said first processor is operative to provide a prompt signal which specifies the illuminated light-emitting elements.

17. The apparatus defined in claim 9, wherein said first processor is operative to alter the duration of illumination of said light source.

18. The apparatus defined in claim 1, wherein said prompt producing device is a display screen for displaying a representation of digitized information.

19. The apparatus defined in claim 1, wherein

(i) said prompt producing device comprises a display screen; and

(ii) said first processor causes said display device to produce an image whose visualization by said PHI requires the PHI to change a visual focus, and thereby to cause an anatomic change in said PHI iris;

whereby focusing by said PHI on said image produces said anatomic change in the configuration of said PHI iris.

20. The apparatus defined in claim 1, wherein first processor is operative to randomly generate prompt signals during said given period of time.

21. The apparatus defined in claim 1, wherein said first processor is operative to generate prompt signals with a pseudo-random pattern during said given period of time.

22. The apparatus defined in claim 1, wherein

(i) said first processor is further operative to identify a spatial pattern of blood vessels of a retina of an eye of the RHI and the PHI;

(ii) said computer database is further operative to store a plurality of images of said retinal blood vessels of a RHI, each image obtained under different lighting conditions;

(iii) said prompt producing device comprises a light source configured to generate light in response to said at least one prompt signal, which light impinges on said PHI iris thereby to alter an opening size of said PHI iris, and thereby to alter the size of the field of viewable retinal vessels; and

wherein said first processor is further operative to change lighting conditions of said PHI iris by generating said at least one prompt signal;

whereby said first processor is operative to compare a plurality of viewed PHI test images of said retinal vessels, each under different lighting conditions, with a plurality of stored retinal vessel RHI images;

thereby to determine whether said PHI is or is not the same individual as said RHI.

23. The apparatus defined in claim 1, wherein

(i) said prompt producing device is configured to apply a painful stimulus to said PHI, thereby to cause an anatomic change in said PHI iris; and

(ii) wherein said first processor is further operative to cause said prompt device to apply said painful stimulus by generating said at least one prompt signal;

whereby said first processor is operative to compare data representing a plurality of images of said PHI iris with data representing a plurality of stored RHI iris images.

21

24. The apparatus defined in claim 1, wherein

- (i) said computer database is operative to store data representing a plurality of images of an iris of an eye of said RHI, each image obtained with said iris oriented at a different angle with respect to a second camera that obtained the stored RHI iris images; and
- (ii) said prompt producing device comprises a display device;
- (iii) said first processor is further operative to cause said display device to produce a plurality of images whose observation by said PHI requires the PHI to change a direction of sight, and thereby to change the spatial orientation of said PHI iris with respect to said at least one first camera; and
- (iv) said first processor is further operative to compare
 - (1) a plurality of images of said PHI iris, each with different spatial orientation of said PHI iris with respect to said at least one first camera, with
 - (2) said stored RHI images;
 whereby attention by said PHI to said plurality of images produces changes in the appearance of said iris; thereby to verify that said PHI is or is not the same individual as said RHI.

25. The apparatus defined in claim 1, wherein

- (i) said computer database is further operative to store data representing a plurality of images of an iris of an eye of said RHI, each image obtained with a different angulation from a line defining the plane of said RHI iris;
- (ii) said prompt producing device comprises a display device;
- (iii) said first processor is further operative to cause said display device to display an instruction whose execution by said PHI requires the PHI to change a direction of sight, and thereby to change the spatial orientation of said PHI iris with respect to said at least one first camera; and
- (iv) said first processor is further operative to compare
 - (1) a plurality of images of said PHI iris, each with different spatial orientation of said PHI iris, with
 - (2) said stored RHI images;
 whereby execution of said instruction by said PHI results in changes in the appearance of said iris.

26. The apparatus defined in claim 1, wherein

- (i) said first camera is further operative to provide an image of a face of the RHI and the PHI;
- (ii) said prompt producing device further comprises a display screen;
- (iii) said first processor is further operative to cause said display device to produce a plurality of images whose observation by said PHI requires the PHI to change a direction of sight, and thereby to change at least one of (a) an eye orientation with respect to a face of said PHI, and (b) an orientation of a face of said PHI with respect to said at least one first camera;
- (iv) said computer database is further operative to store RHI facial images of said RHI, obtained during the variation of at least one of (a) an eye orientation with respect to a face of said RHI, and (b) an orientation of a face of said RHI with respect to a second camera that obtained the stored RHI facial images; and
- (v) said first processor is further operative to compare a plurality of said PHI facial images with said stored RHI facial images; whereby attention by said PHI to said plurality of images produces an additional changeable visible identifying feature.

22

27. The apparatus defined in claim 1, wherein

- (i) said first camera is further operative to provide an image of a face of the RHI and the PHI;
- (ii) said prompt producing device further comprises a display screen;
- (iii) said first processor is further operative to cause said display device to display an instruction whose execution by said PHI requires the PHI to change a direction of sight, and thereby to change at least one of (a) an eye orientation with respect to a face of said PHI, and (b) an orientation of a face of said PHI with respect to said at least one first camera;
- (iv) said computer database is further operative to store RHI facial images of said RHI, obtained during the variation of at least one of (a) an eye orientation with respect to a face of said RHI, and (b) an orientation of a face of said RHI with respect to a second camera that obtained the stored RHI facial images; and
- (v) said first processor is further operative to compare a plurality of said PHI facial images with said stored RHI facial images; whereby execution of said instruction by said PHI results in said change in said PHI facial images.

28. The apparatus in claim 1, wherein said first processor is further operative to generate a signal containing information which indicates the result of said comparison of said test images with said stored images.

29. The apparatus defined in claim 1, further comprising a first input device, coupled to said first processor, for inputting information to said processor.

30. The apparatus defined in claim 1, wherein said first processor is operative to store information in said computer database.

31. The apparatus defined in claim 30, wherein said first processor is further operative to store identification information in said computer database, pertaining to a registration person who is permitted to store information in said computer database.

32. The apparatus in claim 1, wherein said first processor is further operative to cause the transmission of signals to said PHI representing secure information only if said first processor repeatedly verifies the identity of said PHI during said given period of time.

33. The apparatus defined in claim 32, further comprising a computer memory, coupled to said first processor, for storing said secure information, and for accessing said secure information therefrom.

34. The apparatus defined in claim 32 further comprising a digital memory device, operative to communicate with said first processor and located in proximity to said PHI for receiving and storing said secure information.

35. The apparatus defined in claim 4, further comprising a memory device, coupled to said second processor, for receiving and storing secure information;

wherein

- (a) said first processor is further operative to cause the transmission of signals to said PHI representing said secure information only if said first processor repeatedly verifies the identity of said PHI during said given period of time; and
- (b) said second processor is further operative to (i) receive said secure information, (ii) store said secure information in said memory device and (iii) access said secure information therefrom.

36. The apparatus defined in claim 32, wherein said first processor is further operative to interrupt the transmission of

23

said signals representing secure information to said PHI, if said first processor does not verify the identity of said PHI.

37. The apparatus defined in claim 1, further comprising a display device located in proximity to said PHI, for displaying a first representation of code information received from said first processor;

wherein

- (i) said first processor is further operative to generate a first representation of code information for transmission to said display device;
- (ii) said at least one first camera is arranged to view said display device in addition to said PHI such that said test image includes both (a) a visible identifying feature of said PHI, and (b) an image of said first representation of said displayed code;
- (iii) said first processor is further operative to generate both (a) a second representation of said code, and (b) a representation of said image of said PHI, from each of said received test images;
- (iv) said first processor is further operative to compare information contained in said first representation of said code with information contained in said second representation of said code; and
- (v) said first processor is further operative to generate a signal containing comparison information which indicates the result of said comparison.

38. The apparatus defined in claim 37, wherein said code information specifies a secure message to said PHI.

39. The apparatus in claim 37, wherein said first processor is further operative to cause the transmission of signals to said PHI representing secure information only if said first processor

- (a) verifies that the information contained in said second representation of said code represents the information contained in said first representation of said code; and
- (b) repeatedly verifies the identity of said PHI during said given period of time.

40. The apparatus defined in claim 39, wherein said first processor is further operative to interrupt the transmission of said secure information to said PHI, if said first processor does not

- (a) verify that the information contained in said second representation of said code represents the information contained in said first representation of said code; and
- (b) repeatedly verify the identity of said PHI during said given period of time.

41. The apparatus defined in claim 37, wherein said code is generated by generating at least one pseudorandom number.

42. The apparatus defined in claim 37, wherein said first processor is coupled to a weather input device, and said code is generated based on weather information.

43. The apparatus defined in claim 37, wherein said first processor is coupled to a stock market input device, and said code is generated based on stock market information.

44. The apparatus defined in claim 37, wherein said first processor is coupled to a astronomic data input device, and said code is generated based on astronomic information.

45. The apparatus defined in claim 37, wherein said first processor is coupled to a athletic event data input device, and said code is generated based on athletic event information.

46. The apparatus defined in claim 37, wherein said first processor is coupled to a traffic input device, and said code is generated based on traffic information.

47. The apparatus defined in claim 37, wherein said apparatus further comprises a white noise generating device

24

coupled to said first processor, and wherein said code is generated by digitizing the output of said noise generating device.

48. The apparatus defined in claim 37, wherein said code repeatedly changes, and wherein said processor is operative to compare each generated version of said code with each respective second representation of said code.

49. The apparatus defined in claim 1, further comprising a light projection device located in proximity to said PHI, for projecting a first representation of code information received from said first processor onto a reflective surface of said PHI; wherein

- (i) said first processor is further operative to generate a first representation of code information for transmission to said projection device;
- (ii) said at least one first camera is arranged to view said PHI such that said test image includes both (a) a visible identifying feature of said PHI, and (b) a reflected image from said surface of said PHI of said projected first representation of said code;
- (iii) said first processor is further operative to generate both (a) a second representation of said code, and (b) a representation of said image of said PHI, from each of said received test images;
- (iv) said first processor is further operative to compare information contained in said first representation of said code with information contained in said second representation of said code; and
- (v) said first processor is further operative to generate a signal containing comparison information which indicates the result of said comparison.

50. The apparatus defined in claim 49, wherein said light projection device is oriented such that light emitted from said device is (a) reflected from a cornea of an eye of said PHI, and (b) thereafter impinges on said at least one first camera;

whereby said at least one first camera provides test images, each of which comprises both said visible identifying feature and said reflected image of said projected first representation of said code.

51. The apparatus defined in claim 49, further comprising a light reflective element reversibly attached to said PHI, and positioned in proximity to said visible identifying feature of said PHI, such that light emitted from said projection device is (a) reflected from said reflective element, and (b) thereafter impinges on said at least one first camera;

whereby said at least one first camera provides test images, each of which comprises both said visible identifying feature and said reflected image of said projected first representation of said code.

52. The apparatus defined in claim 1 comprising at least two first cameras, including

- (a) a primary first camera arranged to view said visible PHI identifying feature from a first spatial orientation with respect to the location of said PHI, and
- (b) a secondary first camera arranged to view said visible PHI identifying feature from a second spatial orientation with respect to the location of said PHI,

each camera operative to repeatedly generate successive test images of said identifying feature of said PHI during said given period of time for transmission to said first processor;

wherein

- (i) said computer database is operative to store (a) a first plurality of RHI images of said identifying feature obtained with said first spatial orientation, and (b) a

25

second plurality of RHI images of said identifying feature obtained with said second spatial orientation, and

- (ii) said first processor is operative to receive and repeatedly compare each of said successive test images of said identifying feature of said PHI received from said at least two first cameras, with said respective stored plurality of images of the identifying feature of said at least one RHI to repeatedly verify the identity of the PHI during said given period of time.

53. The apparatus defined in claim 52, wherein said first processor is further operative to generate calculated RHI images from each of (a) at least one of said first plurality of stored RHI images, and (b) at least one of said second plurality of stored RHI images; and to repeatedly compare said PHI test images with both said stored and said calculated PHI images.

54. The apparatus defined in claim 52, wherein said first processor is further operative to generate calculated PHI images from each of (a) at least one test image received from said primary first camera, and (b) at least one of test image received from said secondary first camera; and to repeatedly compare said stored RHI images with both said received PHI images and said calculated PHI images.

55. The apparatus defined in claim 1 further comprising an additional first camera arranged (1) to view an additional visible PHI identifying feature of said PHI, and (2) to repeatedly generate successive test images of said additional identifying feature of said PHI during said given period of time for transmission to said first processor;

wherein

- (i) said computer database is further operative to store a plurality of RHI images of said additional identifying feature; and
- (ii) said first processor is further operative to receive and repeatedly compare each of said successive test images of said additional identifying feature of said PHI received from said additional first camera, with said stored plurality of images of the additional identifying feature of said at least one RHI to repeatedly verify the identity of the PHI during said given period of time;

thereby to provide PHI identification based on two different visible identifying features.

56. The apparatus defined in claim 1 further comprising a security camera arranged (1) to view said at least one first camera and said identifying feature of said PHI, and (2) to repeatedly generate successive security images, each said image including both (a) said at least one first camera and (b) said identifying feature of said PHI during said given period of time for transmission to said first processor;

wherein

- (i) said computer database is further operative to store a plurality of (a) RHI images as viewed from the position of said security camera, with respect to the position of said PHI; and (b) images of said at least one first camera, as viewed from the position of said security camera; and
- (ii) said first processor is further operative to receive and generate both (a) a security representation of said PHI identifying feature, and (b) a security representation of said at least one first camera, from each of said received security images;
- (iii) said first processor is further operative to repeatedly compare (a) each of said successive security representations of said PHI identifying feature with the RHI identifying images in said database, and (b) each of

26

said successive security representations of said at least one first camera with the camera images in said database; and

- (iv) said first processor is further operative to indicate the results of said comparisons; thereby to repeatedly verify the identity of the PHI during said given period of time, and to repeatedly verify that each of said at least one first camera and said PHI has not been subject to tampering.

57. The apparatus defined in claim 56, wherein said at least one first camera further comprises a camera display screen for displaying a first representation of security code information received from said first processor, said screen (a) attached to an outer surface of a housing of said at least one first camera, and (b) positioned and oriented so that it may be viewed by said security camera;

wherein

- (i) said first processor is further operative to generate a first representation of security code information for transmission to said camera display screen;
- (ii) each of said successive security images includes each of (a) said identifying feature of said PHI, (b) said image of said at least one first camera, and (c) said first representation of security code information;
- (iii) said first processor is further operative to generate each of (a) a second representation of said security code, (b) said image of said at least one first camera, and (c) the representation of said image of said PHI, from each of said received security images;
- (iv) said first processor is further operative to compare information contained in said first representation of said security code with information contained in said second representation of said security code; and
- (v) said first processor is further operative to generate a signal containing comparison information which indicates the result of said comparison.

58. The apparatus defined in claim 56, wherein said security camera further comprises a security display screen for displaying a first representation of additional security code information received from said first processor, said security display screen (a) attached to an outer surface of a housing of said security camera, and (b) positioned and oriented so that it may be viewed by said at least one first camera;

wherein

- (i) said first processor is further operative to generate a first representation of additional security code information for transmission to said security display screen;
- (ii) each of said successive test images includes each of (a) said identifying feature of said PHI, (b) said image of said security camera, and (c) said first representation of said additional security code information;
- (iii) said first processor is further operative to generate both (a) a second representation of said additional security code, and (b) the representation of said image of said PHI, from each of said received security images;
- (iv) said first processor is further operative to compare information contained in said first representation of said additional security code with information contained in said second representation of said additional security code; and
- (v) said first processor is further operative to generate a signal containing comparison information which indicates the result of said comparison.

59. The apparatus defined in claim 5, wherein said prompt producing device comprises a sound producing device, for

27

providing an instruction to said PHI, whose execution by said PHI results in a change in at least one of (i) the appearance, and (ii) the position of said identifying feature, and wherein said first processor is operative to provide said instruction for transmission to said prompt producing device.

60. The apparatus defined in claim 59, wherein said first processor is coupled to an input device for the input of information which results in the provision of said instruction.

61. The apparatus defined in claim 5, wherein

- (i) at least two of said identifying features are selected from the group consisting of:
 - (a) at least one fingerprint,
 - (b) at least one palm print,
 - (c) a facial image,
 - (d) a pattern of blood vessels of at least one hand,
 - (e) a pattern of retinal veins of at least one eye,
 - (f) a pattern of an iris of at least one eye, and
 - (g) a pattern of blood vessels of a sclera of at least one eye;

of the PHI and of the PHI;

- (ii) said computer database stores a plurality of images of at least two of said identifying features of said RHI; and
- (iii) said prompt producing device provides an instruction, received from said first processor, to said PHI to move a

28

- body part so that a geometric relationship between said two PHI identifying images is altered by said movement;
- (iv) said first processor is further operative to provide said instruction for transmission to said prompt producing device; and
- (v) said first processor is operative to receive and repeatedly compare each of said two PHI test images obtained during said movement with a plurality of stored RHI images of said identifying features; thereby to verify that said PHI is or is not the same individual as said RHI.

62. The apparatus defined in claim 1, wherein said apparatus is operative to repeatedly verify the identity of said PHI; wherein said first processor is operative to

- (A) generate at least one additional prompt signal for transmission to said prompt producing device;
- (B) thereafter to generate a respective additional post-prompt representation of a test image of said iris, corresponding to said at least one additional post-prompt signal; and
- (C) thereafter to compare data representing at least one of said additional post-prompt representations with data representing at least one other of said test images.

* * * * *